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THE RELATIONSHIP OF GENERAL AVIATION-ASSOCIATED PRODUCTS AND SE--ETC(U)
SEP 80 F BERARDINO, J BENTLEY, G DANK DOT-FA78WA-4218

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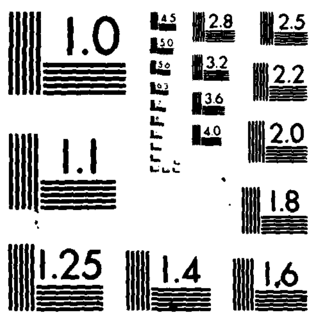

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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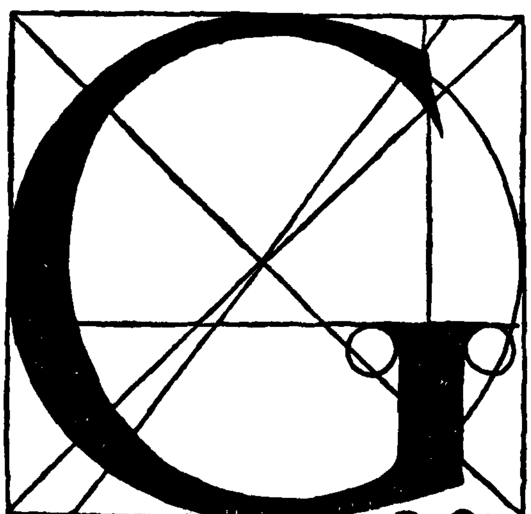

Leonardo drawing of the letter G from "Divina Proportione," Venice, 1509

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Gellman Research Associates, Inc.

THE RELATIONSHIP OF GENERAL AVIATION-ASSOCIATED PRODUCTS AND SERVICES TO THE NATIONAL ECONOMY, 1977

Frank Berardino and Jerome Bentley
with
Gloria Dank, Frederick Tiffany and Richard Abrams

Final Report

Prepared under Contract No. DOT-FA78WA-4218

September 8, 1980

Prepared for:

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF EXHIBITS

LIST OF EXHIBITS (continued)

LIST OF EXHIBITS (continued)

CHAPTER 1

INTRODUCTION AND SUMMARY OF RESULTS

INTRODUCTION AND SUMMARY OF RESULTS

Introduction

This study addresses two questions:

- o What were the contributions made by the general aviation (GA) industry to the Gross National Product (GNP) and Gross National Income (GNI) in 1977?
- o What were the aggregate resource savings and consumer benefits (to the economy) attributable to the use of general aviation in 1977?

To answer the first question requires measuring the economic activity in the general aviation industry in the year 1977. Answering the second question requires estimating economic losses that would have occurred in the absence of the general aviation industry in 1977. Because these questions are different, two separate sets of methodologies were developed to answer them.

Measuring the GNI and GNP Contribution of General Aviation

In 1977, there were approximately 190,000 general aviation aircraft in active use in the United States. The owners and operators of these aircraft purchased services and goods from literally thousands of companies. It is the economic activity of these companies produced in support of general aviation activity which must be measured in order to determine the GNI and GNP contribution of the general aviation industry. Also included in these estimates are the contributions made by various government entities in support of general aviation activity.

These private and government entities have been divided into the following general aviation industry segments:

- Fixed-base operators, which provide the following services:
  - aircraft repairs,
  - fueling,
  - flight training,
  - aircraft rental,
  - new and used aircraft sales,
  - new avionics sales,
  - aircraft sheltering and tie-downs,
  - air taxi services, and
  - private airport-related facilities;
- Aircraft manufacturers;
- Avionics manufacturers;
- Commuter airlines which provide scheduled air transportation services (as opposed to the unscheduled services provided by air taxi operators);
- Insurance companies;
- Banks and other financial intermediaries;
- Professional pilot services provided to aircraft owners;
- Government airport enterprises;
- General government services.

All of these entities provide inputs into the production of general aviation goods and services. The value of these inputs--wages, profits, interest, rent, depreciation and indirect business taxes--is the contribution of the GA industry to Gross National Income. For example, the GNI contribution of an FBO is essentially the sum of the value of its inputs, which is found on the firm's income statement.

The entities which make up the GA industry produce goods and services, some of which are sold to final users (final goods and services) while others are used by other firms in their production processes (intermediate goods and services). The GNP contribution of the GA industry is the market value of final goods and services produced by the GA industries. For example, if an aircraft manufacturer sells an airplane directly to an individual, the GNP contribution is the value of the airplane and is attributed to the manufacturer. On the other hand, if the aircraft manufacturer sells the same airplane to an FBO, who then resells it to an individual, only the value of the sale made by the FBO is counted as a contribution to GNP. The sale of the airplane by the manufacturer to the FBO is ignored because otherwise the value of the same airplane would be counted twice.

These definitions of GNI and GNP contribution are consistent with those employed by the Bureau of Economic Analysis, U.S. Department of Commerce. Hence, the GNI and GNP estimates for the general aviation industry are a consistent subset of estimates of total GNI and GNP developed by the Commerce Department.

Exhibit 1-1 presents a summary of the estimates of GNI and GNP contributions of the GA industry in 1977. The GNI contribution of $3,790.8 million is the income generated within the GA industry. It does not include the value of the inputs purchased outside of the GA industry. The GNP contribution of $3,662.8 million is the value of the retail sales (or final goods and services) sold by the GA industry. It does include the value of some intermediate products, but excludes any sales made to other industries for use in their production processes.

Measuring the Resource Savings and Consumer Benefits Due to the Use of General Aviation Aircraft

The second topic addressed in this study is the aggregate economic gains attributable to the use of general aviation aircraft. These gains can take the form of either resource savings (lower production costs) or unique additions to the satisfaction of consumers.

Resource savings due to the use of GA aircraft depend directly on the activity or "use category" in which an aircraft is involved, and on the probable substitutes which could be used in lieu of the aircraft. Exhibit 1-2 shows the use categories defined by the FAA, together with the percent of total GA activity each one accounts for and the probable substitutes that could be selected in the absence of the airplane.

These resource savings attributable to the use of general aviation aircraft are traceable in the economy. In the absence of general aviation, the cost of the production of the various

Exhibit 1-1

SUMMARY OF ESTIMATES OF GNI AND GNP CONTRIBUTION MADE BY THE GENERAL AVIATION INDUSTRY

($ Millions)

	GNI Contribution	GNP Contribution
FBO TOTAL	1,323.3	2,460.6
o Airframe and Avionics Repair	275.5	49.2
o Engine Repairs	169.5	37.4
o Fuel Sales	70.3	101.7
o New Aircraft Sales	146.9	1,378.4
o Used Aircraft Sales	217.6	217.6
o After-Market Avionics Sales	42.2	29.6
o Tie-Downs and Hangaring	263.6	95.7
o Air Taxi, Rental, Flight Instruction	137.7	553.2
Aircraft Manufacturing	751.0	488.5
Avionics Manufacturing	64.9	*
Commuter Airlines	320.0	184.5
Insurance Companies	73.0	60.7
Banking Services	460.2	*
Professional Pilot Services	338.4	*
Government Airport Enterprises	99.1	105.4
General Government	360.9	360.9
TOTALS (1977)	3,790.8	3,662.8

*Production in these GA segments is made up of intermediate products. The value of these products is attributed to other GA segments or other industries based on who sells the product or service to its final user.

Exhibit 1-2

GA USE CATEGORIES AND SUBSTITUTES

Use Category	Percent of Total GA Activity*	Probable Substitutes
Business/Executive	32	Commercial Airlines Automobile Railroad Bus
Personal	25	Other Recreation or Transportation
Aerial Application	5	Land Vehicles
Instructional	16	None
Commuter/Taxi	8	Commercial Airlines Automobile Railroad Bus
Industrial/Special	3	Varies Depending on Activity
Rental	9	Commercial Airlines Automobile Railroad Bus
Other	2	Varies Depending on Activity

*Hours in flight (1976) were used as a measure of activity.

Source: Selected Statistics, U.S. General Aviation 1959-1976, (January 1978). Federal Aviation Administration, Figures may not sum to 100 because of rounding.

goods and services produced within the use categories would be either higher or lower. Measuring the resource savings or loss due to the general aviation aircraft is a matter of measuring the total cost of production both with and without the aircraft. For example, the cost of planting and fertilizing certain foodstuffs can be higher if agricultural aircraft are not employed.

The benefit attributable to personal use is the satisfaction a consumer enjoys from utilizing his airplane. Benefits from personal use are measured by "consumer surplus," which is defined as the difference between what consumers would be willing to spend and the actual price of flying. In other words, consumer surplus is a measure of the satisfaction that GA users derive from personal flying over and above the money they spend on it.

Exhibit 1-3 presents the estimates of resource savings and consumer benefits attributable to general aviation. The resource savings estimate of $1,312.5 million is the additional costs that the economy would incur if GA aircraft were not employed in other industry production functions. Some industrial and special uses of general aviation aircraft are not included in these estimates because it was impossible to consider all the production processes in which GA aircraft are involved. The estimate of consumer benefits of $1,039.6 million is a measure of the net value of recreational flying to personal users.

The following two chapters present detailed descriptions of how these estimates were derived.

Exhibit 1-3

SUMMARY OF ESTIMATES OF RESOURCE SAVINGS AND CONSUMER BENEFITS ATTRIBUTABLE TO GENERAL AVIATION

($ Millions)

	Resource Savings	Consumer Benefits
Business and Executive Transportation	859.5	-
Agricultural Aviation	284.8	-
Gulf Coast Helicopter Industry	23.7	-
Air Taxi and Aircraft Rental	144.5	280.1
Personal Transportation	-	759.5
TOTALS (1977)	1,312.5	1,039.6

CHAPTER 2

GNI AND GNP ESTIMATES FOR THE GENERAL AVIATION INDUSTRY IN 1977

INTRODUCTION

In this chapter, the GNP and GNI contributions of the GA industry are derived. The industry has been divided into the following segments:

- o fixed-base operators,
- o aircraft manufacturers,
- o avionics manufacturers,
- o commuter airlines,
- o insurance companies,
- o banks and other financial institutions,
- o professional pilot services provided to aircraft owners,
- o government-airport enterprises,
- o general government services.

Some of these industry segments provide intermediate products for the production of goods and services either by other GA industry segments or by other industries. That is, not all sales made by GA are sales of final goods. As a result, in general the GNI contribution (the value of the inputs utilized) will not equal the GNP contribution (the value of the final--as opposed to intermediate--products) for any one segment. In some cases, the differences between GNI and GNP contributions can be quite large.[1] However, these differences between GNI and GNP contributions are

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[1]The differences between GNI and GNP contribution can be accounted for by tracing the flows of income and output in each segment. Generally, this is made evident in the tables below.

consistent with the conventions of national income accounting employed by the Commerce Department. The results of this report therefore can be compared to and used with Commerce Department statistics.

The general approach to making estimates of GNI and GNP contributions was to rely to the extent feasible on direct information--e.g., balance sheets, income statements, trade association sales figures, etc. Inevitably, however, it was necessary to piece together bits of information from disparate sources to complete the analyses of some industry segments. Details on these sources are presented in the exhibits.

FIXED BASE OPERATORS

Fixed base operators (FBO's) are the retailers of the general aviation industry. They purchase goods from several other general aviation firms--e.g., airframe, avionics manufacturers, fuel and parts suppliers--and then resell them to the general aviation consumer. In order to derive the GNI and GNP contribution for FBO's, it has been necessary to perform detailed studies of several of these suppliers. Statistics from FAA sources and from surveys performed for the National Air Transportation Association (NATA) by Gellman Research Associates were also employed.

For many of the services and goods sold by FBO's, the only source of information on pricing was the survey which GRA performed for NATA.[1] Respondents were asked to price specific goods or services they provide. The questions were designed to distinguish between purchased inputs and the services actually performed by the FBO. As a result, it was possible to derive both value added (and therefore the GNI contribution) of the FBO and the total retail value of the service in question. The survey results are considered representative of the FBO industry.

Goods and services provided by the FBO's have been segregated into eight categories:

- o airframe and avionics repairs,
- o engine repairs,

---

[1]NATA, "Analysis of Competition in and Profile of the FBO Industry" (1979).

- fuel sales,
- new aircraft sales,
- used aircraft sales,
- avionics after-market sales,
- tie-downs and hangaring,
- air taxi,
- flight instruction,
- aircraft rental.

Exhibit 2-1 is a summary table showing retail sales and GNI and GNP contributions made by the FBO industry in each of these categories. Care should be taken in interpreting these results. Notice, for example, that new aircraft sales account for approximately half of the GNP contribution of the FBO industry. This large contribution to GNP has imbedded in it significant value added by aircraft manufacturers and suppliers. The large contribution is properly allocated to the FBO industry because it is the retail outlet for aircraft manufacturers, but no one should interpret this large contribution as being reflective of the value added by the FBO industry alone.

Details of the economic activity for each of the FBO services are shown in the following exhibits.

Airframe and Avionics Repairs

Exhibit 2-2 shows the economic activity in the performance of airframe and avionics repairs by FBO's. The methods used are illustrative of those employed in the development of estimates

Exhibit 2-1

FBO CONTRIBUTIONS TO GNI AND GNP ($ MILLIONS)

Services	Sales	FBO Contributions to: GNI	GNP
Airframe and Avionics Repairs	398.4	275.5	49.2
Engine Repairs	308.3	169.5	37.4
Fuel Sales	719.6	70.3	101.7
New Aircraft Sales	1631.6*	146.9	1,378.4**
Used Aircraft Sales	1972.8	217.6	217.6
After-Market Avionics Sales	96.5	42.2	27.4
Tie-Downs and Hangaring	263.6	263.6	95.7
Air Taxi, Rental, Flight Instruction	1,140.0	137.7***	553.2
Totals	6,530.8	1,323.3	2460.6

*Includes domestic sales and markups of imported aircraft, and factory installed avionics.

**Includes manufacturer and supplier contributions detailed in aircraft manufacturer section.

***Includes only wages and profits from these activities; all other inputs valued in other FBO activities--e.g., fuel, repairs--or other industry segments--e.g., insurance, interest.

Exhibit 2-2

FBO CONTRIBUTION TO GNI AND GNP: AIRFRAME AND AVIONIC REPAIRS

	Hours	Airframe/ Avionics Reserve Per Hour	Airframe/ Avionics Repairs (Millions)	Percent FBO Value Added[a]	Percent Supplier Value Added[a]	FBO Value Added (Millions)	Supplier Value Added (Millions)	Percent Personal Hours	FBO Contribution to Consumption (Millions)	Supplier Contribution to Consumption (Millions)
Single Engine Piston, 1-3 Seats	7,746,801	$ 3.37	$ 26.09	69.1	30.9	$ 18.03	$ 8.05	27.3	$ 4.92	$ 2.20
Single Engine Piston, More Than 3 Seats	17,045,260	5.29	90.21	69.1	30.9	62.34	27.87	34.6	21.57	9.64
Twin Piston	5,577,108	17.56	97.91	69.1	30.9	67.66	30.25	8.2	5.55	2.48
Turboprop, Less Than 12,500 lbs.	993,762	51.13	33.39	69.1	30.9	23.08	10.31	2.8	.65	.29
Turboprop, More Than 12,500 lbs.	181,635	144.50	26.25	69.1	30.9	18.40	8.11	1.0	.18	.08
Twin Turbojet, Less Than 20,000 lbs.	403,157	83.71	33.75	69.1	30.9	23.32	10.43	1.3	.30	.14
Twin Turbojet, More Than 20,000 lbs.	261,378	186.77	48.82	69.1	30.9	33.73	15.09	0.5	.17	.08
Multiple Turbojet, More Than 20,000 lbs.	73,012	202.83	14.81	69.1	30.9	10.23	4.58	2.7	.28	.12
Piston Rotary	774,497	17.62	13.65	69.1	30.9	9.43	4.22	3.1	.29	.13
Turbine Rotary	513,184	26.24	13.47	69.1	30.9	9.31	4.16	1.2	.11	.05
Total Airframe and Avionics Repair			398.35							
FBO Contribution to GNI = Total FBO Value Added						275.53				
Supplier Contribution to GNI = Total Supplier Value Added							123.07			
FBO Value Added Consumed									34.02	
Supplier Value Added Consumed										15.21
Total FBO Contribution to GNP										49.23

[a]Weighted by percent of FBO's offering the service, as a surrogate for sales in the two repair categories, based on NATA, "Analysis of Competition in and Profile of the FBO Industry," survey conducted by Gellman Research Associates, Inc. (1978-1979).

All other figures from: FAA, Selected Statistics United States General Aviation 1959-76, DOT-FA77WA-4041 (January, 1978).

for other service categories as well. Information is available on the variable costs of operating different aircraft types in "Selected Statistics United States General Aviation 1959-1976." The same source provides information on hours flown by aircraft categories. Using this information, it is possible to derive the domestic retail value of airframe and avionics repairs in the FBO industry segment. Information from the NATA survey was then utilized to develop value added estimates for FBO's and their suppliers. Summing these value added estimates for all aircraft types yields the GNI contribution by FBO's. On the GNP side, the only final services provided are those sold to personal users (consumption); only the retail value of sales made to personal users are allocated to the GNP contribution of the general aviation industry. Information on the personal use of each aircraft type is available from the same FAA source. The value of all other sales are intermediate products used in the production of other goods and services--e.g., executive and business transportation, agricultural, and industry flying. As a result, services provided to these users are inputs and are not provided to final users.

Engine Repairs and Fuel Sales

Exhibits 2-3 and 2-4 show the estimates of economic activity in these two FBO service categories. The methods used are identical to those employed in the development of estimates for airframe and avionics repairs.

Exhibit 2-3

FBO CONTRIBUTION TO GNI AND GNP: ENGINE REPAIRS

	Hours	Engine Reserve Per Hour	Engine Repair Purchases (Millions)	Percent FBO Value Added[a]	Percent Supplier Value Added[a]	FBO Value Added (Millions)	Supplier Value Added (Millions)	Percent Personal Hours	FBO Contribution to Consumption (Millions)	Supplier Contribution to Consumption (Millions)
Single Engine, 1-3 Seats	7,746,801	$ 2.52	$ 19.55	.55	.45	$ 10.75	$ 8.80	27.3	$ 2.93	$ 2.40
Single Engine, More Than 3 Seats	17,045,260	3.71	63.24	.55	.45	34.78	28.46	34.6	12.03	9.85
Twin Piston	5,577,108	17.17	95.77	.55	.45	52.67	43.10	8.2	4.32	3.53
Turboprop, Less Than 12,500 lbs.	993,762	34.67	34.46	5	.45	18.95	15.51	2.8	.53	.43
Turboprop, More Than 12,500 lbs.	181,635	25.81	4.69	.55	.45	2.58	2.11	1.0	.03	.02
Twin Turbojet, Less Than 20,000 lbs.	403,157	69.36	27.96	.55	.45	15.38	12.58	1.3	.20	.16
Twin Turbojet, More Than 20,000 lbs.	261,378	99.82	26.09	.55	.45	14.35	11.74	0.5	.07	.06
Multiple Turbojet, More Than 20,000 lbs.	73,012	232.02	16.94	.55	.45	9.32	7.62	2.7	.25	.21
Piston Rotary	774,497	6.16	4.77	.55	.45	2.62	2.15	3.1	.08	.07
Turbine Rotary	513,184	28.84	14.80	.55	.45	8.14	6.66	1.2	.10	.08
Total Engine Repair Sales			308.27							
FBO Contribution to GNI = Total FBO Value Added						169.54				
Supplier Contribution to GNI = Total Supplier Value Added							138.73			
Total FBO Value Added Consumed									20.54	
Total Supplier Value Added Consumed										16.81
Total FBO Contribution to GNP										37.35

[a]NATA, survey conducted by Gellman Research Associates, Inc. (1978-1979).

All other figures from: FAA, Selected Statistics, United States General Aviation 1959-76, DOT-FA77WA-4041 (January, 1978).

Exhibit 2-4

FBO CONTRIBUTION TO GNI AND GNP: FUEL SALES

	Hours	Fuel Cost Per Hour	Fuel Purchases (Millions)	Percent FBO Value Added[a]	Percent Supplier Value Added[a]	FBO Value Added (Millions)	Supplier Value Added (Millions)	Percent Personal Hours	FBO Contribution to Consumption (Millions)	Supplier Contribution to Consumption (Millions)
Single Engine, 1-3 Seats	7,746,801	$ 8.95	$ 69.33	9.8[a]	90.2	$ 6.79	$ 62.54	27.3	$1.85	$ 17.05
Single Engine, More Than 3 Seats	17,045,260	11.1[illegible]	189.54	9.8	90.2	18.57	170.97	34.6	6.42	59.16
Twin Piston	5,577,108	27.78	154.92	9.8	90.2	15.18	139.74	8.2	1.24	11.46
Turboprop, Less Than 12,500 lbs.	993,762	51.13	50.81	9.7[b]	90.3	4.93	45.88	2.8	.14	1.28
Turboprop, More Than 12,500 lbs.	181,635	185.65	33.72	9.7	90.3	3.27	30.45	1.0	.03	.30
Twin Turbojet, Less Than 20,000 lbs.	403,157	236.03	95.16	9.7	90.3	9.23	85.93	1.3	.12	1.12
Twin Turbojet, More Than 20,000 lbs.	261,378	311.20	81.34	9.7	90.3	7.89	73.45	0.5	.04	.38
Mult. Engine Turbojet, More Than 20,000 lbs.	73,012	348.15	24.42	9.7	90.3	2.47	21.95	2.7	.07	.60
Piston Rotary	774,497	12.38	9.59	9.8	90.2	.94	8.65	3.1	.03	.27
Turbine Rotary	513,184	21.01	10.78	9.7	90.3	1.05	9.73	1.2	.01	.12
Total Fuel Purchases			719.61							
FBO Contribution to GNI = Total FBO Value Added						70.32				
Supplier Contribution to GNI = Total Supplier Value Added							649.29			
Total FBO Value Added Consumed									9.95	
Total Supplier Value Added Consumed										91.74
Total FBO Contribution to GNP										101.69

[a] Survey conducted by Gellman Research Associates, Inc. (1978-1979).

[b] [illegible]

All other figures from: FAA, Selected Statistics, United States General Aviation 1959-1976, DOT-FA77WA-4041 (January, 1978).

New Aircraft Sales

Exhibit 2-5 illustrates the derivation of the economic activity in the sale of new aircraft. The statistics shown are largely based upon the estimates of sales and value added provided in the section on aircraft manufacture. It should be noted that the estimates include factory-equipped avionics equipment as opposed to such equipment sold in the after-market by FBO's.

The only data shown in Exhibit 2-5 which is not discussed in detail in the section on aircraft manufacture is the FBO markup on the wholesale price of new airplanes and the breakdown of selling expenses and profits. This set of information is derived from the NATA survey discussed above.

Shown at the bottom on Exhibit 2-5 is the GNP contribution of FBO's, aircraft manufacturers and their suppliers as a group. Included in this estimate are exports of aircraft, which are final sales made by aircraft manufacturers to the foreign sector. Therefore, this $488.5 million is technically not part of the FBO industry segment and is allocated only to aircraft manufacturers. The remaining GNP contribution is allocated to the FBO sector and amounts to $1,378.4 million. When taken together, the FBO and aircraft manufacture contributions yield a total contribution of $1,866.9 million. Notice that the domestic retail sales of new aircraft by FBO's is less than the total GNP contribution made by FBO's, manufacturers, and suppliers because of the sale abroad of domestically produced aircraft.

Exhibit 2-5

FBO CONTRIBUTIONS TO GNI AND GNP: NEW AIRCRAFT SALES (INCLUDING FACTORY EQUIPPED AVIONICS)

GNI Contribution of FBO's ($ Millions)

Factory Value of New U.S. Aircraft	1,342.6
Factory Value of New Foreign Aircraft	126.6
Total Factory Value of New Aircraft	1,469.2
Average FBO Markup	10.2%
FBO GNI Contribution	146.9
Selling Expenses	80.7
Profit	66.2

GNP Contribution of FBO's, Aircraft Manufacturers and their Suppliers ($ Millions)

Consumption	144.0
Investment	1,348.4
Exports*	488.5
	1,980.9
Less Imports (At Factory Value)	126.6
	1,854.3
Plus FBO Markup on Imports	12.6
GNP Contribution	1,866.9

GNP Contribution of FBO's Only (Consumption + Investment + Markup on Imports - Imports) = 1,378.4

GNP Contribution of Aircraft Manufacturers Only (Exports) = 488.5

Domestic Retail Sales of FBO's (Consumption + Investment + Imports + Markup on Imports) = 1,631.6

*Domestic FBO's do not generally participate in the sales of these aircraft.

Used Aircraft Sales

Conceptually, the only relevant economic activity produced in the sale of used aircraft is the markup on such aircraft made by fixed base operators. This is the case because the value of the production and income created when the aircraft was first manufactured has already been accounted for at that time, whether in 1977 or in some previous year. Thus, the sale of used aircraft creates only a minor contribution to GNP or GNI.[2]

The methods employed to derive the value of the used aircraft sales are as follows. Using data on the age composition, number, and values of the used aircraft fleet from available FAA sources, and on the average turnover of airplanes as published in an AOPA document, it was possible to derive the value of used aircraft sold in 1977. The value added by FBO's was based on the NATA survey performed by Gellman Research Associates. By summing the value added by aircraft types, it is then possible to derive the contribution to GNI which is identical to the GNP contribution, assuming that none of the airplanes are exported. Appropriate segregation of this value added into consumption and investment proponents for the GNP calculation was derived from FAA statistics on the use of the different aircraft categories. The results are shown in Exhibit 2-6.

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[2] Of course, some aircraft owners find that their aircraft have appreciated over time and therefore they earn a capital gain when the planes are sold. Such capital gains are not returns to a factor of production and therefore are not included as profit or other income in the national accounts.

Exhibit 2-6

FBO CONTRIBUTION TO GNI AND GNP: USED AIRCRAFT SALES

	Representative Year of Manufacture CIRCA 1974 (Millions)	CIRCA 1967 (Millions)	CIRCA 1962 (Millions)	CIRCA 1955 (Millions)	Total Sales Values (Millions)	FBO Value Added (Millions)	Percent of Aircraft in Personal Use	FBO Contribution to Consumption (Millions)	FBO Contribution to Investment (Millions)
Single Engine, 1-3 Seats	$ 59.97	$ 46.49	$ 11.91	$ 38.87	$ 157.24	$ 17.35	57.8	$10.03	$ 7.32
Single Engine, More Than 3 Seats	175.98	185.77	82.14	98.16	542.05	59.81	50.2	30.02	29.79
Twins	217.15	142.89	39.38	25.31	424.73	46.85	15.6	7.31	39.54
Turboprop, Less Than 12,500 lbs.	114.26	69.20	-	-	183.46	20.23	2.2	.45	19.78
Turboprop, More Than 12,500 lbs.	42.41	33.62	3.06	.51	79.61	8.78	1.5	.13	8.65
Twin Turbojet, Less Than 20,000 lbs.	104.44	67.27	5.78	-	177.49	19.58	2.1	.41	19.17
Twin Turbojet, More Than 20,000 lbs.	160.70	78.80	-	-	239.50	26.41	1.1	.29	26.12
Mult. Turbojet, More Than 20,000 lbs.	64.69	42.03	2.01	-	108.73	12.00	1.9	.23	11.77
Piston Rotary	16.53	8.40	3.27	2.00	30.20	3.34	10.2	.34	3.00
Turbine Rotary	21.52	8.26	-	-	29.80	3.29	1.7	.06	3.23
Total Sales Used Aircraft					$1,972.81				
FBO Contribution to GNI						$217.64			
FBO Contribution to GNP									$217.64

Sources: Breakdown of aircraft by age from: Vahovich, S. G., "General Aviation: Aircraft, Owner and Utilization Characteristics," FAA-AVP-76-9 (November, 1976), p. 7-9.

Number of aircraft in fleet percent in personal use and average values from: FAA, Selected Statistics, United States General Aviation 1966-1976, DOT-FA77WA-4041 (January, 1978).

Percent of aircraft sold from: AOPA, "Profile of Flying and Buying" (1978).

FBO value added based on unpublished NATA survey data.

It should be noted that the analysis assumes that all used aircraft are sold by FBO's. While this is clearly not the case, there exists no data on the value of aircraft sold by private individuals. Thus, included in the GNI and GNP calculations are imputed profits earned by private individuals on the sale of depreciated used aircraft.

After-Market Avionics Sales

A distinction has been made between new avionics imbedded in new aircraft and those sold in the after-market primarily by FBO's. This distinction is necessary in order to avoid the double counting of avionics imbedded in new aircraft. The value of factory-installed avionics is already included in the GNI and GNP contribution by FBO's and aircraft manufacturers in the sale of new airplanes. Thus, the only remaining avionics sales to be accounted for are those made in the after market.

Exhibit 2-7 shows the FBO contributions to GNI and GNP due to the after-market sales of avionics. The after-market factory values are based on data shown in the section on avionics manufacturing and on the typical markups employed by distributors and retailers provided by an anonymous industry source. Both the distributor and retail markup have been allocated to the FBO industry segment and are used to derive the GNI contribution. Retail sales are allocated to the consumption sector based on statistics shown in the section on avionics.

Exhibit 2-7

FBO CONTRIBUTION TO GNI AND GNP: AFTER-MARKET AVIONICS SALES

($ Millions)

	After-Market Factory Value	Distribution Markup	Retail Markup	Total FBO GNI Contribution	Retail Sales	Percent Personal Use	FBO (and Supplier) Contribution to GNP
Single Engine	20.6	6.7	13.9	20.6	41.2	52.9	21.8
Multi-Engine Small Turboprop	18.6	6.0	12.5	18.5	37.1	14.0	5.2
Large Turboprop *Turbojet, Rotary*	15.1	1.1	2.0	3.1	18.2	14.4	2.6
Totals				42.2	96.5		29.6

Sources: Factory values are percentages of total factory values shown in Avionics Manufacturing Sections. The percentages used to derive after-market values are from an avionics manufacturer, as are the markups. The markups, however, are close to those found in the NATA survey conducted by Gellman Research Associates, Inc.

Aircraft Tie-Downs and Hangaring

The statistics shown in Exhibit 2-8 are derived from the FAA source indicated. Notice that the total value of purchases for aircraft sheltering is assumed to be equal to the GNI contribution of FBO's. This assumption is believed to be appropriate because there are few purchased inputs made by FBO's in order to provide either tie-downs or hangaring. One might argue that some small proportion of sales is devoted to the purchase of outside services such as electricity, maintenance, and other incidentals. However, it would seem that these purchases from outside sources are relatively minor in that the vast majority of revenues would be used to defray factor and non-factor payments, especially rent and depreciation.

The GNP contributions are based on the percent of aircraft of a given type that are used primarily for personal reasons as opposed to the number of personal hours flown by aircraft categories.

Air Taxi, Flight Instruction and Aircraft Rentals

It was necessary to aggregate these three service categories because they are typically provided by the same pool of aircraft owned by FBO's. Drawing on a pool of aircraft to perform these services is necessary because typically no one of the services could defray the fixed costs of aircraft ownership. Therefore, it seems appropriate to evaluate the profitability and other factor and non-factor payments due to these three services as a group.

Exhibit 2-8

FBO CONTRIBUTION TO GNI AND GNP: AIRCRAFT TIE-DOWN AND HANGARING

	Aircraft	Shelter Cost Per Aircraft	Total Shelter Purchases (Millions)	Percent of Aircraft in Personal Use	FBO Contribution to Consumption (Millions)
Single Engine, 1-3 Seats	51,886	1,020	52.92	57.8	30.60
Single Engine, More Than 3 Seats	94,858	1,176	111.55	50.2	56.05
Twin Piston	20,156	2,525	50.89	15.6	7.91
Turboprop, Less Than 12,500 lbs.	1,849	5,228	9.67	2.2	.21
Turboprop, More Than 12,500 lbs.	263	23,171	6.09	1.5	.09
Twin Turbojet, Less Than 20,000 lbs.	765	16,808	12.86	2.1	.27
Twin Turbojet, More Than 20,000 lbs.	465	18,571	8.64	1.1	.09
Mult. Turbojet, More Than 20,000 lbs.	260	21,049	5.47	1.9	.11
Piston Rotary	3,119	1,154	3.60	10.2	.37
Turbine Rotary	1,260	1,524	1.92	1.7	.03
Total Shelter Purchases					
FBO Contribution to GNI			263.61		
FBO Contribution to GNP					95.73

All figures from: FAA, Selected Statistics, United States General Aviation 1959-76, DOT-FA77WA-4041 (January, 1978).

All of the data used to derive the GNI and GNP contributions are shown in Exhibit 2-9. The notes explain the numerous sources employed in this analysis. The method is relatively straightforward. The variable costs, including pilot wages (line 11), were derived from the data in the previous 10 lines which includes per hour operating expenses, pilot wages, and hours of operation. Data on revenues per hour in lines 12 through 15 were derived by taking average prices from the source indicated. These per hour revenue figures were then multiplied by the number of hours in each service category to derive total revenues in line 16. The contribution to overhead in the following line is simply the difference between total revenues and total variable costs. Total fixed costs in line 20 were derived using FAA statistics on the number of aircraft and fixed costs per airplane. The resulting profit estimates are shown in line 21 and are the difference between contribution to overhead (which includes profits) and fixed costs.

Shown in line 22 is the air service incremental GNI. This includes only wages and profits since the other factor and non-factor inputs have already been accounted for either in the estimates for FBO services--e.g., fuel--or for other services such as banking and insurance. The GNP contribution is the percent of total hours accounted for by consumption activities multiplied by total revenues in line 16.

Interpretation of Results

Measures of economic activity in the FBO industry segment shown in Exhibit 2-1 are far larger than for any other industry

Exhibit 2-9

FBO CONTRIBUTION TO GNI AND GNP: AIR TAXI, FLIGHT INSTRUCTION, AIRCRAFT RENTAL

	Single-Engine Piston 1-3 Seats	Single-Engine Piston +3 Seats	Twin Piston	Twin Turboprop	Twin Turbojet	Piston Rotary	Turbine Rotary*	Totals
(1) Variable Costs Per Hour Without Pilot	14.84	20.42	62.51	119.41	389.10	36.16	108.06	
(2) Air Taxi Pilot Wage/Hr.	14.00	14.00	14.00	14.00	28.00	14.00	14.00	
(3) Flight Instructor Wage/Hr.	11.64	11.64	11.46	-	-	14.00	14.00	
(4) Air Taxi Hours	12,553	834,000	1,119,260	78,555	213,883	37,404	648,811	
(5) Dual Flight Instruction Hours	1,627,582	1,103,945	119,551	-	-	18,384	85,777	
(6) Solo Flight Instruction Hours	1,627,582	1,103,945	119,551	7,159	55,326	18,384	85,777	
(7) Rental Hours	503,180	1,913,162	160,186	77,975	-	2,705	8,786	
(8) Total Air Taxi Pilot Wages ($M)	.17	11.68	15.67	1.09	5.99	0.52	9.08	
(9) Total Flight Instructor Wages ($M)	18.95	12.85	1.37	-	-	0.26	1.20	
(10) Total Variable Costs Without Pilots ($M)	55.98	101.18	94.92	19.55	104.75	2.78	89.59	
(11) Total Variable Costs ($M)	74.93	125.71	111.96	20.64	110.74	3.56	99.87	
(12) Air Taxi Revenues Per Hour	39.85	70.67	175.24	323.50	656.90	175.49	331.92	
(13) Dual Instruction Revenue Per Hour	41.59	51.86	132.25	-	-	113.75	230.58	
(14) Solo Instruction Revenue Per Hour	29.95	40.22	120.79	240.00	633.30	99.75	216.58	
(15) Rental Revenue Per Hour	29.95	40.22	120.79	240.00	633.30	99.75	216.58	
(16) Total Revenues ($M)	132.01	237.54	245.74	50.70	208.93	9.51	255.61	1,140.04
(17) Contribution to Overhead ($M)	57.08	111.83	133.78	30.06	98.19	5.95	155.74	
(18) Number of Aircraft	10,306	13,976	3,418	135	270	729	1,055	
(19) Average Fixed Costs	7,673	10,207	39,648	123,276	179,116	16,496	97,675	
(20) Total Fixed Costs ($M)	79.08	142.65	135.52	16.64	48.36	12.03	103.05	
(21) Profit ($M)	(22.00)	(30.82)	(1.74)	13.42	49.83	(2.52)	52.69	
(22) Air Service Incremental GNI** ($M)	(2.88)	(6.29)	15.30	14.51	55.82	(1.74)	62.97	137.69
(23) Percent of Flight Hours for Consumption***	30.13	42.03	41.73	46.02	38.34	26.53	38.32	
(24) Air Service GNP Contribution ($M)	39.78	99.83	102.55	110.46	80.11	2.52	97.94	533.19

*Using Bell 212 as being typical turbine rotary helicopter.

**Includes only pilot wages and profits; other GNI contributions made by FBO's to other factors and non-factors already accounted for in other tables--e.g., fuel, repairs, insurance, etc.

*** $.48 \frac{\text{(Air Taxi Hours + Rental Hours) + (Percent of Hours in Personal Use)(Flight Instruction Hours)}}{\text{Total Air Taxi Hours + Rental Hours + Flight Instruction Hours}}$ 48% based on ATA Survey of purpose of trips taken via air carriers.

Sources: Lines 1, 4, 5, 6, 7, 18 and 19 from FAA, Selected Statistics, United States General Aviation 1959-76, DOT-FA77WA-4041 (January, 1978). Line 4 does not include commuter hours, which were deducted based on commuter flight hours (CAB) and the composition of the commuter fleet [CAAA, "Annual Report of the Commuter Airline Industry" (1978)]
Line 2 from NATA, unpublished survey conducted by Gellman Research Associates, Inc. (1978-1979).
Line 3 based on telephone survey of schools in the Philadelphia area.
Lines 12, 13, 14, 15 from ACTION, "The Air Taxi Charter and Rental Directory of North America" (1975).

segment. This is the case because FBO's are the retailers for the general aviation industry. They therefore provide a number of goods and services which are supplied to them by a number of other general aviation industry segments. One should not be misled by the huge dollar figures for either FBO retail sales or GNP contribution since both include the considerable value added by other supplying industry segments. A more accurate picture of the economic activity taking place in the FBO industry segment is the GNI contribution which is really the value of the goods and services produced solely by the FBO's. Looked at in this light, FBO's provide approximately 20 percent of the value-added of the sales they make. Put another way, for every dollar of sales made by an FBO, approximately 20¢ of that dollar is produced at the FBO facility.

AIRCRAFT MANUFACTURING

General aviation aircraft are those manufactured primarily for use by anyone other than certificated air carriers[1] or the military. They include airplanes and helicopters employed by commuter airlines and air taxi operators, as well as those used for business/executive, personal or industrial/special flying. This section presents the calculations used to derive estimates of contribution of this industry segment to GNI and GNP. Calculations for airplane and helicopter manufacturing are made separately and then added to the final result so that the relative contribution of each can be distinguished.

Calculations in this section were originally intended to be based on value-added statements derived from annual reports. However, sufficient data were not available from these reports for three reasons. First, companies which are not publicly owned were unwilling to supply annual reports. Second, some manufacturers are owned by large holding companies, which do not report a sufficient set of financial data for their subsidiaries in either annual reports or in 10-K reports submitted to the SEC. In such cases it was often impossible to isolate data for the subsidiary

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[1]"Certificated carriers" here refers to trunk, regional and local service carriers in 1977. It does not refer to any commuter airlines, even though some had certificates for specific routes at that time.

which produces general aviation aircraft. Finally, even corporations which primarily produce general aviation aircraft did not always provide sufficient data. For example, some of the reports did not break down costs in enough detail to be used in value-added statements. In addition, even companies such as Cessna or Gates-Learjet have lines of business other than manufacturing aircraft. Gates-Learjet, for example, owns fixed base operations and Cessna manufactures avionics. The annual reports did not always contain enough information to separate these lines of business from aircraft manufacturing. Some of these companies also make significant sales to the military, but do not report them separately.

The above limitations made it necessary to rely upon data from the General Aviation Manufacturer's Association (GAMA) and the Aerospace Industries Association (AIA) for company sales and aircraft revenue figures. Available annual reports were used to calculate various cost and revenue categories as percentages of either value-added or total revenue. These percentages were calculated for each company which provided a usable annual report, and an industry average was applied to sales and revenue figures for those which did not.

Calculations

Aircraft Sales

For the reasons cited above, figures on 1976 and 1977 factory billings[2] for general aviation aircraft were obtained from AIA and GAMA.[3] They are presented in Exhibit 2-10.

Figures for both years were obtained in order to estimate factory billings for the fiscal year of each company.[4] This step is depicted in Exhibit 2-11. For each company, the fiscal year having the most months in calendar 1977 was chosen for the calculation. It was then assumed that sales were distributed evenly throughout each calendar year. Using this assumption, the company's sales for each calendar year were multiplied by the proportion of that year falling within the company's fiscal year.[5] The two portions were then added together. For example, Beech Aircraft Corporation's fiscal year ends on September 30. Therefore, fiscal

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[2]Factory billings constitute the revenue derived by the manufacturer from the sale of aircraft to distributors or dealers. They are not equivalent to retail sales revenue which includes the markups of distributors and dealers.

[3]Aerospace Industries Association of America, Inc., Aerospace Facts and Figures 1978/79 (New York: Aviation Week and Space Technology, 1978), p. 35; and General Aviation Manufacturer's Association, Inc., General Aviation Airplane Shipment Report, December 1976 and December 1977. Certain figures from the 1977 report were updated from unpublished GAMA data.

[4]Calculations were based on fiscal years so that factory billings could later be compared with the revenues given in annual reports. An estimate of the revenue derived from business other than aircraft manufacturing was the result.

[5]Although it is not known whether sales are distributed evenly, it would not be reasonable to construct estimates for fiscal years from annual data without such an assumption. As explained in the introduction, sales figures had to be calculated this way because annual reports were not available for all companies.

Exhibit 2-10

MANUFACTURERS' BILLINGS FOR GENERAL AVIATION AIRCRAFT
CALENDAR YEARS 1976-77

Manufacturer	1976 Billings ($ mil.)	1977 Billings ($ mil.)
Beech	236.096	262.700
Bellanca	6.812	5.478
Cessna	382.658	483.015
Gates-Learjet	119.989	168.582
Grumman-American	112.070	119.126
Lake	3.344	4.151
Lockheed	17.066	81.968
Maule	2.285	2.812
Mooney	n.a.[a]	n.a.[a]
Piper	209.565	259.229
Rockwell	119.218	128.631
Swearingen	19.593	35.391
Ted Smith	17.164	19.004

[a]Not Available

Sources: GAMA and AIA figures.

Exhibit 2-11

ESTIMATES OF MANUFACTURER'S NET BILLINGS FOR EACH COMPANY'S FISCAL YEAR

($ mil.)

Manufacturer (Fiscal Year Ending)	Portion from 1st Calendar Year	Portion from 2nd Calendar Year	Estimated Billings for Fiscal Year Closest to Calendar Year
Beech (Sept. 30, 1977)	59.024	197.025	256.049
Cessna (Sept. 30, 1977	95.664	362.261	457.925
Gates-Learjet (April 30, 1978)[a]	111.264	65.682	176.946
Grumman-American (Dec. 31, 1977)	119.126	0	119.126
Piper (Sept. 30, 1977)	52.391	194.422	246.813
Swearingen (Dec. 31, 1977)	35.391	0	35.391
Others (Sept. 30, 1977)[b]	41.472	181.533	222.405
			1514.655

[a]Figures for 1978 were taken from the GAMA report for that year.

[b]Assumption, based on fact that Rockwell, which is the largest contributor to this category, has a September 30 fiscal year.

1977 was chosen for this company. The 1976 factory billings of $236.096 mil. were multiplied by .25 and the 1977 billings of $262.7 mil. were multiplied by .75. The estimated factory billings for Beech were $59.024 mil. + $197.025 mil. = $256.049 mil.

A separate estimate was made for those companies which could not provide usable annual reports. The revenues of these companies in each year were added together and the above procedure was applied based on the assumption of a September 30 fiscal year.[6] These companies are listed together as "others" in Exhibit 2-11.[7]

The far right-hand column of Exhibit 2-11 contains the final estimates for factory billings during the fiscal year closest to 1977. The total for the industry is $1.514 billion.

Revenues and Costs

Where possible, estimates of total company revenue, and allocations of cost to such categories as wages, taxes, and depreciation, were based on annual reports. These reports were used to construct value-added statements such as the one for Cessna, shown in Exhibit 2-12. The numbers shown are estimates because the report did not contain direct data for all of the categories, nor did it separate Cessna's aircraft manufacturing from other general aviation business.

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[6] Justification for this assumption came from the fact that Rockwell, the largest contributor to the "Others" category, has a September 30 fiscal year. The fiscal years of the other firms were unknown.

[7] The "Others" category includes: Bellanca, Lake, Lockheed, Maule, Mooney, Rockwell, and Ted Smith.

Exhibit 2-12

STATEMENT OF VALUE-ADDED DUE TO GENERAL AVIATION AIRCRAFT PRODUCTION BY CESSNA AIRCRAFT COMPANY, 1977

Uses of Income ($ mil.)		
Factor Costs		
Employee Compensation		172.015
Interest		10.146
Rents		n.a.[a]
Corporate Profits Before Taxes		70.469
Tax Liability	36.051	
Dividends	8.736	
Retained Earnings	25.682	
Contribution to GNI		252.630
Non-Factor Costs		
Depreciation		5.946
Indirect Business Taxes		15.342
Total Factor and Non-Factor Costs		273.918

Sources of Income ($ mil.)	
Sales and Other Income	543.222
Inventory Change	53.361
Total Income	596.583
Less: Purchased Materials and Services Consumed in Production Process	322.665
Gross Value-Added	273.918

[a] Not Available

Source: Estimates based on Cessna annual report for 1977.

The left-hand column of Exhibit 2-12 shows the uses of income (or cost categories). These are divided into payments to factors of production (land, labor and capital) and non-factor payments. By far the largest factor payment is to labor.

Gross value-added can also be calculated from the right-hand column. The first entry in this column consists of sales and other income related to general aviation. The value of inventory accumulation (or depletion) is added to (or subtracted from) this column to obtain total income from general aviation products in fiscal 1977. Gross value-added is obtained by subtracting the value of purchased (or "intermediate") materials and services used in production.

Exhibit 2-13 summarizes all the value-added statements which were constructed. For each company, it also shows each cost category as a percentage of gross value-added, as well as purchased materials and services as a percentage of total sales and inventory change. The mean of these percentages for each category was used in estimating a combined income statement for the companies which did not provide annual reports.

The combined statement is shown as the "Others" column of Exhibit 2-13. Total sales and inventory change were calculated by adding an estimate of the change in inventory for these firms to their factory billings as calculated in Exhibit 2-11.[8] This

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[8]The inventory change was estimated as a percentage of factory billings based on the average percentage (5.7%) for firms which provided annual reports.

Exhibit 2-13

SUMMARY OF ESTIMATED VALUE-ADDED STATEMENTS

	Beech		Cessna		Gates-Learjet		Grumman-Am.		Piper		Swearingen		Others		
	$(mil.)	%	$(mil.)	%	$(mil.)	%	$(mil.)	%	$(mil.)	%	$(mil.)	%	$(mil.)	Mean %	Total
Total Sales, Inventory Change, and Other Income	343.419		596.583		227.078		169.704		272.690		41.522		235.082		1886.078
Purchased Materials and Services	193.142	56.2[a]	322.665	54.1	145.040	63.9	103.762	61.1	148.500	54.4	21.804	52.5	133.997	57.0	1068.910
Contribution to GNI (Value Added Less Non-Factor Payments)	146.434	%	252.630	%	77.927	%	64.690	%	113.560	%	19.552	%	96.132	%	770.925
Employee Compensation	104.080	69.3[b]	172.015	62.8	55.375	67.5	52.601	79.8	79.170	63.7	12.866	65.2	68.839	68.1	544.946
Net Interest	-.720	-.5	10.146	3.7	1.365	1.7	1.528	2.3	3.350	2.7	-.115	-.6	1.516	1.5	17.070
Rents	2.285	1.5	n.a.	n.a.	2.803	3.4	2.183	3.3	3.200	2.6	.246	1.2	2.426	2.4	13.143
Corporate Profits (Before Taxes)	40.789	27.1	70.469	25.7	18.384	22.4	8.378	12.7	27.840	22.4	6.555	33.2	24.159	23.9	196.574
Depreciation	2.643	1.8	5.946	2.1	2.886	3.5	1.252	1.9	3.820	3.1	.085	.4	2.123	2.1	18.755
Indirect Business Taxes	1.20	.8	15.342	5.6	1.225	1.5	n.a.	n.a.	6.810	5.5	.081	.4	2.830	2.8	27.488

[a]Purchased materials and services as percentage of total sales, inventory change, and other income.

[b]Employee compensation and other cost categories as percentage of contribution to GNI.

Source: Individual company estimates based on company annual reports for fiscal 1977. "Others" based on AIA and GAMA figures, and percentage allocations.

sum was then allocated among the cost categories according to the percentages shown in the "Mean %" column. Purchased materials and services were calculated as a percentage of total sales and inventory change based on the mean percentage for companies providing annual reports.[9]

The far right-hand column of Exhibit 2-13 shows industry totals. But these are not final estimates because the sales and inventory change figures include some business other than aircraft manufacturing. The following section describes the calculations used to separate aircraft sales from other business.

Separation of Aircraft Sales from Other Business

The calculations in this section were necessary because estimates of total general aviation income, based on annual reports, were greater than estimates of general aviation aircraft sales revenue, based on AIA and GAMA figures. There are two possible reasons for this discrepancy. First, some of the discrepancy may be due to the assumption of a constant rate of sales throughout the year. The second and more important reason is that many aircraft manufacturing firms engage in other general aviation-related businesses which they do not report separately from aircraft manufacturing. For example, Gates-Learjet controls three major fixed-

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[9] The cost categories for "Others" add to more than the contribution to gross value-added because the mean percentages used to allocate add to 100.8%. This slight discrepancy also exists in the "Totals" column.

base operations, but consolidates income from them with aircraft sales revenue in its annual report.

Since AIA and GAMA figures were the only data available for all manufacturing firms, they were the basis for the final estimates. The first step, depicted in Exhibit 2-14, was to subtract sales estimates based on AIA and GAMA data from estimates of sales and other income based on annual reports. The remainder represented revenue that cannot be attributed to aircraft sales.

These figures, however, did not include any provision for change in inventory, since the figures from AIA and GAMA do not include this factor. On the assumption that inventories exist for non-aircraft business, the change in inventory estimated from each company's annual report was allocated between aircraft and non-aircraft revenue as shown in Exhibit 2-15. A similar allocation of purchased materials and services is depicted in Exhibit 2-16.

Given these calculations, final estimates of each company's contribution to GNI were made. Exhibit 2-17 shows each company's contribution based entirely on aircraft sales. Allocations to cost categories were made according to the percentages calculated earlier from annual reports. The column for "Others" is identical to the same column in Exhibit 2-13, since the original estimates for these companies were based only on sales. The contribution of each company derived from non-aircraft business is shown in Exhibit 2-18.[10]

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[10] Addition of the two exhibits will not yield Exhibit 4 exactly, because percentage allocations were used to estimate the cost categories in Exhibits 2-17 and 2-18.

Exhibit 2-14

SEPARATION OF AIRCRAFT AND NON-AIRCRAFT GENERAL AVIATION REVENUE

Manufacturer (Fiscal Year Ending)[a]	G. A. Related Sales[b] and Other Income	Manufacturers Net Billings for Comparable Year	Non-Aircraft Revenue (% of Sales and Other Income)
Beech (Sept. 30, 1977)	328.530	256.049	72.481 (22.1)
Cessna (Sept. 30, 1977)	543.222	457.925	85.297 (15.7)
Gates-Learjet (April 30, 1978)	228.042[c]	176.946	51.096 (22.4)
Grumman-American (Dec. 31, 1977)	169.704[d]	119.126	50.578 (29.8)
Piper (Sept. 30, 1977)	267.6	246.813	20.787 (7.8)
Swearingen (Dec. 31, 1978)	38.145	35.391	2.754 (7.2)
Totals	1575.243	1292.250	282.993

[a] Fiscal year with most months in 1977.

[b] Derived from financial reports. Does not include change in inventory.

[c] This figure is larger than sales and inventory change because inventory change is estimated at $ .964 million.

[d] Same as in Exhibit 4 because no data on change in inventory available.

Sources: Company Annual Reports, AIA and GAMA figures.

Exhibit 2-15

ALLOCATION OF CHANGE IN INVENTORY BETWEEN AIRCRAFT SALES AND NON-AIRCRAFT GENERAL AVIATION REVENUE

Manufacturer	Change in Inventory	Aircraft Sales as Percent of Total G. A. Income	Change in Inventory Allocated to Aircraft Sales	Change in Inventory Allocated to Non-Aircraft Revenue	Change in Inventory Plus Aircraft Sales	Change in Inventory Plus Non-Aircraft Revenue
Beech	14.889	77.9%	11.494	3.395	267.543	75.876
Cessna	53.361	84.3%	44.983	8.378	502.908	93.675
Gates-Learjet	- .961	77.6%	- .746	- .215	176.200	50.881
Grumman-American	n.a.	70.2%	n.a.	n.a.	119.126	50.578
Piper	5.1	92.2%	4.702	.398	251.515	21.185
Swearingen	3.377	92.8%	3.134	.243	38.525	2.997

Exhibit 2-16

ALLOCATION OF PURCHASED MATERIALS AND SERVICES BETWEEN AIRCRAFT SALES AND NON-AIRCRAFT GENERAL AVIATION REVENUE

Manufacturer	Purchased Materials and Services	Aircraft Sales as Percent of Total General Aviation Sales	Purchased Materials and Services Allocated to Aircraft Sales	Purchased Materials and Services Allocated to Non-Aircraft Revenue
Beech	193.142	77.9%	150.458	42.684
Cessna	322.665	84.3%	272.007	50.658
Gates-Learjet	145.040	77.6%	112.551	32.489
Grumman-American	103.762	70.2%	72.841	30.921
Piper	148.500	92.2%	136.917	11.583
Swearingen	21.804	92.8%	20.234	1.57

Exhibit 2-17

CONTRIBUTIONS TO GNI FOR GA AIRCRAFT MANUFACTURERS

	Beech		Cessna		Gates-Learjet		Grumman Am.		Piper		Swearingen		Others	Mean	Total
	$(Mil)	%	$(Mil)	%	$(Mil)	%	$(Mil)	%	$(Mil)	%	$(Mil)	%	$(Mil)		
Total Sales & Inventory Change	267.543		502.908		176.200		119.126		251.515		38.525		235.082		1590.899
Purchased Materials and Services	150.458	56.2[a]	272.007	54.1	112.551	63.9	72.841	61.1	136.917	54.4	20.234	52.5	133.997	57.0	899.005
Contribution to GNI (Value Added Less Non-Factor Payments)	114.041		213.122		60.466		45.406		104.743		18.145		96.132		652.055
Employee Compensation	81.140	69.3[b]	145.006	62.8	42.963	67.5	36.935	79.8	72.999	63.7	11.944	65.3	68.839	68.1	459.826
Net Interest	-.585	-.5	8.543	3.7	1.082	1.7	1.065	2.3	3.094	2.7	-.110	-.6	1.516	1.5	14.605
Rents	1.756	1.5	N.A.	N.A.	2.164	3.4	1.527	3.3	2.979	2.6	.219	1.2	2.426	2.4	11.071
Corporate Profits (Before Taxes)	31.730	27.1	59.342	25.7	14.257	22.4	5.878	12.7	25.670	22.4	6.073	33.2	24.159	23.9	167.109
Depreciation	2.107	1.8	4.849	2.1	2.228	3.5	.879	1.9	3.552	3.1	.073	.4	2.123	2.1	15.811
Indirect Business Taxes	.937	.8	12.930	5.6	.955	1.5	N.A.	N.A.	6.303	5.5	.073	.4	2.830	2.8	24.028

[a] Purchased Materials and Services as percentage of Total Sales and Inventory Change.

[b] Employee Compensation and other cost categories as percentage of Contribution to GNI.

[c] Components of GNP contribution do not add exactly to this number because there is a slight rounding error due to use of percentage allocation.

Exhibit 2-18

CONTRIBUTIONS TO GNI FOR NON-AIRCRAFT BUSINESS

	Beech		Cessna		Gates-Learjet		Grumman-Am.		Piper		Swearingen		
	$(mil.)	%	$(mil.)	%	$(mil.)	%	$(mil.)	%	$(mil.)	%	$(mil.)	%	Total
Total Sales, Inventory Change, and Other Income	75.876		93.675		50.[illegible]		50.578		21.185		2.997		295.192
Purchased Materials and Services	42.684	56.2[a]	50.658	54.1	32.489	63.9	30.921	61.1	11.583	54.4	1.570	52.5	169.905
Contribution to GNP (Total Value Added)	33.192		43.017[c]		18.392		19.657		9.602		1.427[c]		125.287
Contribution to GNI (Value-Added Less Non-Factor Payments)	32.329		39.705		16.768		19.070		8.606		1.415		117.893
Employee Compensation	23.002	69.3[b]	27.015	62.8	12.415	67.5	15.686	79.8	6.116	63.7	.932	65.3	85.166
Net Interest	-.166	-.5	1.592	3.7	.313	1.7	.452	2.3	.259	2.7	-.009	-.6	2.441
Rents	.498	1.5	n.a.	n.a.	.625	3.4	.649	3.3	.250	2.6	.017	1.2	2.039
Corporate Profits (Before Taxes)	8.995	27.1	11.055	25.7	4.120	22.4	2.496	12.7	2.151	22.4	.474	33.2	29.291
Depreciation	.597	1.8	.903	2.1	.644	3.5	.373	1.9	.298	3.1	.006	.4	2.821
Indirect Business Taxes	.266	.8	2.409	5.6	.276	1.5	n.a.	n.a.	.528	5.5	.006	.4	3.485

[a] Purchased materials and services as percentage of total sales and inventory change.

[b] Employee compensation and other cost categories as percentage of contribution to GNP.

[c] Components of GNP contribution do not add exactly to this number because there is a slight rounding error due to use of percentage allocation.

Exhibit 2-19 summarizes the results of the calculations. The non-aircraft revenue cannot be explained precisely. It is probably a combination of non-aircraft, general aviation-related business and the error inherent in estimating sales from AIA and GAMA data.

Contributions of Helicopter Production

It was not possible to acquire cost and revenue data for civilian helicopter production from individual companies. Government and industry association sources were also unable to provide data for individual firms. The best available information, therefore, was an AIA estimate of $316 million in civil helicopter factory billings for 1977. This number includes seven Bell AH-15 and twelve CH-47C helicopters worth approximately $76 million. Because these are military aircraft, their value is subtracted from the AIA estimate yielding GA factory billings of $240 million. This number was allocated to factor and non-factor payments using the percentages calculated above for the aircraft manufacturing industry with the results shown in Exhibit 2-20.

The final estimates for the contribution of aircraft manufacturing to GNI are given in Exhibit 2-21. These numbers are the sum of the airplane manufacturing totals in Exhibit 2-19 and the estimates for helicopter manufacturing in Exhibit 2-20.

Exhibit 2-19

SUMMARY OF GNI CONTRIBUTIONS OF
AIRCRAFT MANUFACTURERS
($ Millions)

	Aircraft Sales	Non-Aircraft Revenue	Total
Total Sales, change in Inventory and Other Income	1590.899	295.192	1886.091
Purchased Materials and Services	899.005	169.905	1068.910
Contribution to GNI	652.055	117.893	769.948
Employee Compensation	459.826	85.166	544.992
Net Interest	14.605	2.441	17.046
Rents	11.071	2.039	13.110
Corporate Profits (Before Taxes)	167.109	29.291	196.400
Depreciation	15.811	2.821	18.632
Indirect Business Taxes	24.028	3.485	27.513

Exhibit 2-20

CONTRIBUTIONS TO GNI FROM CIVILIAN HELICOPTER MANUFACTURING

($ Millions)

Total Factory Billings	240.0
Purchased Materials and Services	136.8
Contribution to GNI (Value-Added Less Non-Factor Payments)	98.97
Employee Compensation	70.28
Net Interest	1.55
Rents	2.48
Corporate Profits (Before Taxes)	24.66
Depreciation	2.17
Indirect Business Taxes	2.89

Source: Allocation of AIA figure (from Aerospace Facts and Figures 1978/1979, p. 34), according to mean industry percentages.

Exhibit 2-21

FINAL ESTIMATES FOR CONTRIBUTION TO GNI OF GENERAL AVIATION AIRCRAFT MANUFACTURERS

($ Millions)

	Total*	Aircraft Sales Only
Total Sales, Change in Inventory and Other Income	2126.091	1830.899
Purchased Materials and Services	1205.71	1035.805
Contribution to GNI	868.918	751.025
Employee Compensation	615.272	530.106
Net Interest	18.596	16.155
Rents	15.59	13.551
Corporate Profits (Before Taxes)	221.06	191.769
Depreciation	20.802	17.981
Indirect Business Taxes	30.403	26.918

*Does not include military or other non-GA sales by helicopter manufacturers.

Contribution to GNP

The steps involved in allocating manufacturer and supplier output to the consumption, investment and export sectors of the economy were as follows:

- o Factory billings were allocated to aircraft types. This step was necessary because the use patterns among aircraft types are different. For example, aircraft consumption activity includes only personal use, the majority of which is done in piston aircraft. The allocations are shown in Exhibits 2-22 and 2-23. For fixed-wing aircraft, average factory net values (excluding distributor and FBO markups) were derived from the sources indicated and applied to the actual number of aircraft produced. For helicopters, each plane type produced was valued separately based on prices (discounted for distributor and FBO markups) published by Lloyds of London.
- o Exports of each aircraft type were derived from AIA data. (See Exhibit 2-23A.)
- o Domestic and export factory billings were then broken down into manufacturer and supplier value-added components based on the ratio of total purchased materials to sales found in Exhibit 2-21.
- o The allocation to sectors of the economy was made in the following way. Domestic sales were divided between

Exhibit 2-22

ALLOCATION OF SALES TO AIRCRAFT TYPES

Aircraft Type	Number Produced	Average Factory Net Value*	Factory Billing ($ Millions)
Single Engine	14,057	32,180	452.37
Multi-Engine	2,195	169,228	371.46
Turboprop	428	707,494	302.81
Turbojet	227	1,893,951	429.92
Piston Rotary**	257	-	15.227
Turbine Rotary**	608	-	225.091
TOTAL			1796.878
Inventory Change and Other Income			34.339

*Federal Aviation Administration, Selected Statistics United States General Aviation 1959-1976; Annual Report, Gates-Learjet Inc. (1977); Lloyds Aviation Department, "Aircraft Types and Prices;" GAMA, Press Releases January 9, 1978.

**See Exhibit 2-23.

Exhibit 2-23

HELICOPTER PRODUCTION AND SALES

Piston	Number Produced*	Value**	Factory Billing ($ Millions)
Brantly 2B	1	44,055	.044
Enstrom F28A	1	53,550	.054
Enstrom 28C	43	61,200	2.632
Enstrom 280C	52	67,902	3.531
Hiller 12E	35	69,750	2.441
Hughes 300	125	52,200	6.525
TOTAL PISTON	257	-	15.227
Turbine			
Bell 205	28	621,000	17.388
Bell 206	283	191,250	54.124
Bell 212	47	850,500	39.974
Bell 214	9	1,181,250	10.631
Hiller 12(E)	5	103,500	.518
Hughes 500	211	171,000	36.081
Sikorsky 561	25	2,655,000	66.375
TOTAL TURBINE	608		
GRAND TOTAL	865		240.318

*Aerospace Industries Association of America; Aerospace Facts and Figures 1978/1979.

**Lloyds Aviation Department; "Aircraft Types and Prices."

Exhibit 2-23A

DOMESTIC AND FOREIGN PURCHASES OF GA AIRCRAFT

	Factory Billings	Exports*	Domestic Use
Single Engine	452.37	93.1	359.27
Multi-Engine	371.46	97.5	273.96
Turboprop	302.81	79.5	223.31
Turbojet	429.92	112.9	317.02
Rotary Piston	15.227	6.68	8.547
Rotary Turbine	225.091	98.82	126.271

*Aerospace Industries Association of America, Aerospace Facts and Figures 1978/1979.

consumption (personal use) and investment (all other uses including some government purchases) based on the proportion of each aircraft type devoted either to personal use or all other uses. This information is found in Selected Statistics United States General Aviation 1959-1976 published by the FAA. The implicit assumption is that new sales paralleled the use patterns by aircraft types as reported for 1976. The allocations to each sector are the value-added contribution of aircraft manufacturers and their suppliers to domestic GNP (see Exhibit 2-24). But most of these aircraft are sold through FBO dealers or distributors.

- The sales of domestically produced aircraft in the U.S. sold through FBO's and distributors were then subtracted from the total to yield the final sales by manufacturers. These final sales are equal to exports.

Care should be taken in interpreting these results. The contribution to GNP shown in Exhibit 2-24 includes both manufacturer and their suppliers' value added. Not all of the GNP contribution is made by GA firms. Instead, aluminum manufacturers, electrical subcontractors and other suppliers, all of whom are in other industries, provide a significant proportion of value added. The aircraft manufacturers themselves contributed $815.9 million in value added before imports.

Exhibit 2-24

PORTION OF GNP CONTRIBUTION DUE TO AIRCRAFT SALES PRODUCED BY AIRCRAFT MANUFACTURERS AND THEIR SUPPLIERS

	Consumption		Investment		Exports		
	Aircraft	Suppliers	Aircraft	Suppliers	Aircraft	Suppliers	Totals
Single Engine	31.9	41.4	124.4	161.6	40.5	52.6	452.4
Multi-Engine	17.9	23.2	101.3	131.6	42.5	55.1	371.6
Turboprop	2.0	2.6	95.1	123.5	34.6	44.9	302.7
Turbojet	3.3	4.3	134.6	174.8	49.1	63.8	429.9
Rotary Piston	0.4	0.5	3.3	4.4	2.9	3.8	15.3
Rotary Turbine	0.9	1.2	54.0	70.1	42.9	55.8	224.9
Inventory Accumulation	—	—	34.3	—	—	—	34.3
TOTALS	56.4	73.2	547.0	666.0	212.5	276.0	1831.1
Less: Aircraft Sold Through FBO's in U.S.							1342.6
Contribution of Aircraft Manufacturers and their Suppliers to Domestic GNP (Equals Exports)							488.5[a]

[a]AIA, Aerospace Facts and Figures 1978/79. Includes some transports up to 33,000 pounds.

AVIONICS MANUFACTURERS

It was even more difficult to obtain data for avionics manufacturers than it was for aircraft manufacturers. Of the firms which comprise this industry segment (listed in Exhibit 2-25), only three provided annual reports. Two of these firms, Narco Avionics and King Radio, account for 65 percent of the market. However, many assumptions were necessary in order to obtain useful estimates of value-added due to general aviation from these firm's annual reports. Since no published sales figures were available, revenues for companies which did not provide annual reports were estimated from information provided by another manufacturer.

Calculations

The first three columns of Exhibit 2-26 summarize the estimated value-added due to general aviation for the three companies (Narco, King, and Wulfsberg) which provided annual reports. The figures in the column marked "Others" were obtained by applying mean percentages to an estimate of these firms' general-aviation-related sales and change in inventory based on information provided by an avionics source. The calculations made to obtain this estimate are summarized in Exhibits 2-27, 2-28, and 2-29.

Exhibit 2-27 lists the initial information obtained from the avionics manufacturer and from annual reports. The total

Exhibit 2-25

FIRMS WHICH PRODUCE GENERAL AVIATION AVIONICS

Narco Avionics--A Division of Narco Scientific Industries

King Radio Corporation

Collins General Aviation Avionics--Division of Rockwell International Corp.

The Bendix Corporation--Aerospace Electronics Group

RCA

Edo Corporation, Edo-Aire Group

Cessna Aircraft Company--Aircraft Radio and Control Division (ARC)

Wulfsberg Electronics, Inc.

Several Small Firms

Exhibit 2-26

ESTIMATES OF GA-RELATED USES OF INCOME AND CONTRIBUTIONS TO GNI FOR AVIONICS INDUSTRY

	Narco		King		Wulfsberg		Others		Total
	$ (mil.)	%	$ (mil.)	%	$ (mil.)	%	$ (mil.)	Mean %	$ (mil.)
Total GA-Related Sales, Change in Inventory, & Other Income	30.340		55.757		1.301		45.059		132.457
Purchased Materials & Services (Residual Suppliers)	15.140	49.9[b]	26.658	47.8	.637	49.0	22.033	48.9	64.468
Contribution to GNI (Value Added Less Non Factor Payments	14.896		27.225		.626		22.173[d]		64.920
Employee Compensation	13.072	86.0[c]	20.716	71.2	.394	59.4	16.647	72.3	50.829
Net Interest	.198	1.3	.055	.2	.019	2.8	.322	1.4	.594
Rents	.395	2.6	n. a.	n. a.	.012	1.8	.507	2.2	.914
Corporate Profits (Before Taxes)	1.231	8.1	6.454	22.2	.201	30.8	4.697	20.4	12.583
Depreciation	.289	1.9	1.584	5.4	.029	4.4	.898	3.9	2.800
Indirect Business Taxes	n. a.	n. a.	.290	1.0	.009	1.3	.276	1.2	.575

[a] Components of GNI contribution do not add exactly to this number because there is a slight rounding error due to use of percentage allocations.

[b] Purchased materials and services as percentage of total sales, inventory change and other income.

[c] Employee compensation and other cost categories as percentage of contribution to GNP.

[d] Sum of cost categories exceeds this number by 1.170 because mean percentages used to allocate "Others" add to 101.4 percent.

Exhibit 2-27

KNOWN OR ASSUMED INFORMATION

From Industry Source:

Total Retail Market (including sales of C & I, Weather Radar, & Flight Controls by Narco, King, Collins, Bendix, RCA, Edo-Aire, ARC [not including after market], Wulfsberg, & several other small firms)

= $225 mil.

Division of Market

1) Single Engine Aircraft (50% of retail to manufacturers) .50 x $82.5 mil. = $41.25 mil.

2) Multi Engine Piston & Small Turboprop Aircraft (50% of retail to manufacturers) .50 x $82.5 mil. = $41.25 mil.

3) Large Turboprop, Turbojet and Rotary Aircraft (70% of retail to manufacturers) .70 x $60.0 mil. = $42.0 mil.

Approximate Market Shares

1) Single Engine:	Narco -	50%
	King -	30%
	Others -	20%
2) Multi-Engine Piston & Small Turboprop:	Narco -	15%
	King -	70%
	Collins -	10%
	Others -	5%
3) Large Turboprop, Turbojet and Rotary:	King -	40%
	Collins -	50%
	Others -	10%

From Company Financial Reports:

G. A. Related Sales

Narco -	$31.184 mil.
King -	$53.316 mil.
Wulfsberg -	$ 2.645 mil.

Exhibit 2-28

AVIONICS SALES BY COMPANY AND BY AIRCRAFT TYPE

1) Single Engine:

Narco =	$20.625 mil.	=	50.0%
King =	10.797 mil.	=	26.2%
Others =	9.828 mil.	=	23.8%
	$41.25 mil.		

2) Multi-Engine Piston and Small Turboprop:

Narco =	$ 6.1875 mil.	=	15.0%
King =	27.297 mil.	=	66.2%
Collins =	4.125 mil.	=	10.0%
Others =	3.6405 mil.	=	8.8%
	$41.25 mil.		

3) Large Turboprop, Turbojet and Rotary:

King =	$15.222 mil.	=	36.2%
Collins =	21.00 mil.	=	50.0%
Others =	5.778 mil.	=	13.8%
	$42.00 mil.		

Company Totals

Narco	King	Collins	Others
$20.625 mil.	$10.797 mil.	$ 4.125 mil.	$ 9.828 mil.
6.1875 mil.	27.297 mil.	21.000 mil.	3.6405 mil.
	15.222 mil.		5.778 mil.
$26.8125 mil	$53.316 mil.	$25.125 mil.	$19.2465 mil.

Exhibit 2-29

ALLOCATION OF AVIONICS MANUFACTURER AND SUPPLIER VALUE-ADDED TO SECTORS OF THE ECONOMY

($ Millions)

	Consumption (Personal Use)		Investment (Other Uses)	
	Avionics Manufacturers	Suppliers	Avionics Manufacturers	Suppliers
Single Engine Piston	11.15	10.67	9.92	9.50
Multi-Engine Piston and Small Turboprop	2.95	2.82	18.13	17.35
Large Turboprop, Turbo-jet, Rotary	3.09	2.96	18.37	17.58
Inventory Accumulation by Manufacturers	-	-	3.40	3.26
Sub-Totals	17.19	16.45	49.82	47.69
Totals	33.64		97.51	

retail market was estimated at $225 million. This estimate includes all sales by firms in Exhibit 2-25 except for after-market sales by ARC.[1]

The total market divides into three parts according to the type of aircraft for which the avionics are sold. These market segments are:

- o single-engine aircraft,
- o multi-engine piston and small turboprop aircraft,
- o large turboprop, turbojet and rotary aircraft.

The portion of the retail price which a manufacturer receives depends on the market segment in which it is selling. It was estimated that manufacturers receive an average of $.50 for every dollar of sales in the first and second segments of the market and $.70 for every dollar in the third segment. According to the cooperating manufacturer there are retail sales of $82.5 million in each of the first two segments and $60 million in the third segment. When these retail sales figures were multiplied by the percentage of sales reaching the manufacturer in each segment, the results showed factory billings of $41.25 million in segments one and two and $42.0 million in segment three. These calculations are represented under the heading "Division of Market" in Exhibit 2-27.

The manufacturer also estimated market shares for each segment. These are shown in Exhibit 2-27 under the heading "Approximate

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[1]After-market sales are those which replace or upgrade equipment that was installed on an aircraft at the time of its original sale. Most equipment sold by ARC is installed on new Cessna aircraft.

Market Shares." Finally, the exhibit shows the general aviation-related sales (but not change in inventory) estimated for the three companies which provided annual reports.

Exhibit 2-28 shows the final estimates for avionics sales by aircraft type and by company. In some cases--e.g., for King Radio--the information in Exhibit 2-27 was conflicting. In all of these cases, direct information from company financial statements was used to reconcile conflicts.

The sales figures in Exhibit 2-26 also include the effects of inventory changes and other income. In addition, in the same exhibit, the Collins' sales figures are included in the "Others" category.

GNP Allocations

Avionics are essentially investment goods when used in the production of other goods and services. In contrast, when avionics are embodied in aircraft used for personal reasons, they are consumption goods. The allocation of avionics output to the consumption and investment section therefore depends on the breakdown of the fleet into personal and all other use categories. The use pattern by aircraft type are shown below.

Use Patterns[2]

	Personal Use (%)	All Other Uses (%)
Single Engine Piston	52.9	47.1
Multi-Engine Piston and Small Turboprop	14.0	86.0
Large Turboprops, Jets and Rotary	14.4	85.6

Exhibit 2-29 shows the allocation of the value added of avionics manufacturers and their suppliers to the consumption and investment sectors of the economy. Note, however, that no final sales are made by these manufacturers. All output is sold either to FBO's (after-market sales) or to aircraft manufacturers. Therefore, technically the GNP contribution of avionics manufacturers is zero, although the figures in Exhibit 2-29 show the value-added by these manufacturers and their suppliers to GNP.

[2]Federal Aviation Administration, Selected Statistics United States General Aviation 1959-1976 (January 1978).

COMMUTER AIRLINES

According to the Civil Aeronautics Board, in 1977 there were 242 commuter airlines providing services to 3,077 total markets in the U.S. Commuters are the fastest growing portion of the scheduled air transportation industry, and are an integral part of the national air transportation system. In general, they provide scheduled passenger service from low density areas to both large and small communities.

Unlike trunks and local service carriers, most commuter airlines are not publicly owned firms. As a result, there is a relative dearth of information on the financial and operating characteristics of these firms. It has been necessary to piece together the economic activity in this important industry segment from a number of disparate sources. The resulting GNI and GNP estimates therefore are first approximations of the economic activity in the commuter airline industry.

The sources of information can be divided roughly into four categories. The Commuter Airline Association of America (CAAA) collects revenue data from their membership. In 1977, the 137 CAAA members had total revenues of $264.7 million. The majority of these carriers were either all passenger or combination (passenger and freight) carriers. They accounted for approximately

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[1]CAB, "Commuter Air Carrier Traffic Statistics" (1978).

58 percent of the total commuter passengers reported in the CAB statistics.[2] Because their activities are most representative of passenger commuter airlines who do some cargo business, the CAAA revenue figures were extrapolated to include only all-passenger and combination carriers. The $460 million revenue figure shown in Exhibit 2-30 is based upon the CAAA membership revenue information and the percentage of total commuter passengers accounted for by these members (58 percent).

A second set of carriers not adequately represented in the CAAA statistics are all-cargo carriers. In 1977, there were 23 non-CAAA all-cargo carriers accounting for approximately 91 million pounds of cargo carried. GRA performed a survey of five of these carriers which accounted for 50 million pounds of cargo carried. These five carriers had revenues of $16.5 million. Using this data, it was possible to extrapolate to the total revenues of the non-CAAA, all-cargo carriers shown in Exhibit 2-30.

The third distinct set of data is on the Federal Express Corporation, which in 1977 was a unique commuter airline specializing in small-package overnight delivery throughout the continental United States. Technically, Federal Express qualified as a commuter airline because at that time none of its aircraft exceeded 12,500 pounds in gross take-off weight. Because Federal Express is a publicly-held company, it was possible to use actual figures to derive revenues and the other information shown in Exhibit 2-30.

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[2] CAB, "Commuter Air Carrier Traffic Statistics" (1978).

Exhibit 2-30

GNI CONTRIBUTION: COMMUTER AIRLINES

($ Millions)

	Combination and All Passenger Carriers	Non-CAAA All Cargo Carriers	Federal Express[3]	Totals
Revenues	460.0[1]	29.9[2]	109.2	599.1
Labor Compensation	110.4	7.2	30.8	148.4
Profits	23.5	1.5	8.2	33.2
Interest	24.3	1.6	5.9	31.8
Rent	15.6	1.0	13.0	29.6
Total Factor Payments	173.8	11.3	57.9	243.0
Depreciation	62.1	4.0	5.4	71.5
Indirect Business Taxes	4.6	.3	.6	5.5
Total Non-Factor Payments	66.7	4.3	6.0	77.0
Gross Value-Added = GNI Contribution	250.5[4]	15.6[4]	63.9	320.0

[1]CAAA membership data extrapolated to include non-CAAA combination and all passenger carriers based on total passengers carried as shown in: CAB, "Commuter Air Carrier Traffic Statistics" (1978).

[2]Based on GRA survey of eight commuter carriers revenues extrapolated to include non-CAAA all-cargo carriers based on total pounds of cargo carried as shown in CAB, Ibid.

[3]All data except labor compensation based on Federal Express Corporation: "Prospectus Class A Common Shares" (April 12, 1978), White, Weld & Co., Incorporated. Labor compensation based on the same source and employment figures shown in: Federal Express: "Annual Report--1979."

[4]All factor and non-factor payments based on averages derived from a GRA survey of eight commuter air carriers.

The fourth set of data pertains to the factor and non-factor payments made by commuter airlines in 1977. GRA performed an informal survey of eight commuter airlines in order to obtain information on factor and non-factor payments. The information from this survey varied considerably among the various carriers. Therefore, the relative sizes of each of the non-factor and factor payment category are rough estimates. However, the gross value added by the various firms was fairly consistent as a percent of total revenues and so the GNI contribution estimates shown in the first two columns are probably reliable, at least to the extent that the revenue estimates are accurate.

Based on these four sets of information, it was then possible to estimate the GNI contribution made by commuter airlines in 1977. This contribution totals to approximately $320 million in 1977. Of this amount, approximately 20 percent was accounted for by the Federal Express Corporation. At this time, Federal Express is no longer a commuter carrier having obtained permission to fly larger aircraft. To the extent that Federal Express has never been a typical commuter airline--because it operates to points throughout the United States--the GNI contribution overstates the economic activity in the commuter industry as most people typically think of it.

The derivation of the GNP contribution by commuter airlines is based directly on the information in Exhibit 2-30 together with some supplementary information on the sales of airline services to the household sector. First, an assumption was made that any revenues derived from cargo services were not final products, but were instead intermediate products purchased by firms in the course of their normal business. Thus, the revenues derived from the cargo activities of all the carriers shown in Exhibit 2-30 were subtracted from the total commuter revenues to obtain air passenger revenues as shown in Exhibit 2-31. The second step in the derivation of GNP contribution was to allocate air passenger revenues to the business (intermediate product) and household sectors (final product). For this purpose, GRA used information based on air passenger surveys conducted by members of the Air Transport Association. There is reason to suspect that these surveys overstate the percent of sales made by commuter airlines to the household sector. It seems likely that ATA members--trunk and local service airlines--carry a higher proportion of people traveling for personal reasons than do commuter airlines. For example, it is more likely that ATA members carry passengers to vacation places because there are no close substitutes for airline services to distant cities. In contrast, most commuter airline services compete directly with automobile travel, which is more likely to be chosen by households in the relatively short markets in which commuters operate. Although the ATA representatives agreed with this assessment, they could shed no light on the size of the over-estimation based on their surveys. Therefore, the ATA surveys were used to allocate commuter airline services between intermediate and final purchases with the proviso that the GNP contribution of $184.5 million probably overstates sales to the household sector of the economy.

Exhibit 2-31

GNP CONTRIBUTION: COMMUTER AIRLINES
($ Millions)

Total Commuter Revenues[1]	599.1
Less:	
Federal Express Revenues[1]	109.2
Non-CAAA All Cargo Carriers Revenues[1]	29.9
Cargo Carried by Combination Carriers[2]	75.6
Air Passenger Revenues	384.4
Percent Personal Travel[3]	48.0%
GNP Contribution	184.5

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[1] Exhibit 1.

[2] Based on average price per pound of 32.94 for non-CAAA all cargo carriers.

[3] Air Transport Association: Telephone conversation regarding air passenger surveys conducted by member airlines.

INSURANCE

Property, liability and medical insurance premiums paid by general aviation are treated in the national accounts in a unique manner. Essentially, insurance companies act as exchanges between general aviation users. The users pay in premiums to the exchanges who then are responsible for paying any claims incurred. These claim payments are transfers between aircraft owners and therefore do not create either new income or output. The majority of insurance premiums written on general aviation aircraft are paid out as transfers between users.

Thus, only the after claim revenues of insurance companies are utilized in the estimation of the GNI and GNP contributions of the general aviation insurance industry. Data and methods used to estimate the GNI contribution are shown in Exhibit 2-32. Per-aircraft annual costs for insurance from the FAA source cited, together with the number of aircraft, were used to estimate total insurance premiums paid. From this was subtracted the claims incurred by those insurance companies. In order to derive this figure, an average loss percentage of 65 percent was assumed. This figure is based on six years of losses as reported by National Aviation Underwriters, Incorporated, and by AVCO. These two companies are among the largest insurers of general aviation aircraft and are assumed to be representative of the entire industry because all companies subscribe to reinsurance programs in order to spread

Exhibit 2-32

GNI CONTRIBUTION ESTIMATES: INSURANCE

	Aircraft Category	Per Aircraft Annual Cost for Hull & Liability/Med ($)	Number of Aircraft	Total Cost ($)
1)	Single Engine: 1-3 Seats	1,649	51,886	85,560,014
2)	Single Engine: ≥ 3 Seats	2,177	94,858	206,510,000
3)	Twin Piston: ≤ 12,500 TOGW	5,119	20,156	103,180,000
6)*	Twin Turboprop: ≤ 12,500 TOGW	14,817	1,849	27,396,633
7)	Twin Turboprop: ≥ 12,500 TOGW	29,472	263	7,751,136
8)	Twin Turbojet Fan: ≤ 20,000 TOGW	18,024	765	13,788,360
9)	Twin Turbojet Fan: ≥ 20,000 TOGW	35,853	465	16,671,645
11)	Multi Turbojet Fan: ≥ 20,000 TOGW	56,940	260	14,804,400
12)	Piston-Rotary Wing	6,950	3,119	21,677,050
13)	Turbine-Rotary Wing	18,035	1,260	22,724,100
				$ 520.0 mil
			Losses Incurred	338.0 mil
	Purchases by Insurance Companies = Supplier GNI Contribution			109.0 mil
	Insurance Company Gross Value-Added = Insurance Company GNI Contribution			73.0 mil

*No insurance data were available for categories 4, 5, and 10.

Sources: FAA, Selected Statistics United States General Aviation 1959-1976, DOT-FA77WA-4041 (January 1978).

National Aviation Underwriters Inc.: "10K Report--1977" Securities and Exchange Commission.

AVEMCO: "Annual Report--1977".

Piper, R.R.: "A Study of Pricing Strategies at General Aviation Airports" Stanford University Ph. D. Disseration (1971) Appendix II.

risk. Thus, the losses incurred tend to be spread among all companies. The purchases by insurance companies are based upon the same sources and include premiums paid to insurance agents and other incidental purchases. The residual $73 million is the GNI contribution made by insurance companies. The total GNI contribution made by insurance companies and their suppliers is $182 million.

On the GNP side of the accounts, only after claims revenues associated with insurance sold to personal users is included as a final product. All other insurance is accounted for as intermediate products in the production of other final goods and services produced by businesses which own aircraft. These GNP contribution estimates are shown in Exhibit 2-33 and are based upon the same sources indicated in Exhibit 2-32. Notice that both the insurance company and supplier gross value-added are included in the GNP contribution estimate.

At least three observations should be made concerning these GNP and GNI estimates. First, the loss ratio of 65 percent utilized in the analysis is based on a six-year average for the two companies cited in Exhibit 2-32. This average was deemed to be more representative than any single year's loss experience because such losses depend upon the number and type of reinsurance programs subscribed to by specific companies and on the number of policies renewed and begun in any specific year. By taking the average over several years, the loss ratio utilized in the analysis is probably more representative of industry experience. Second,

Exhibit 2-33

GNP CONTRIBUTION ESTIMATE: INSURANCE

	Aircraft Category	Per Aircraft Annual Cost for Hull & Liability/Med ($)	Number of Aircraft	Total Cost ($)
1)	Single Engine: 1-3 Seats	1,649	30,001	49,471,649
2)	Single Engine: ≥ 4 Seats	2,177	47,659	103,753,643
3)	Twin Piston: ≤ 12,500 TOGW	5,119	3,134	16,042,946
6)*	Twin Turboprop: ≤ 12,500 TOGW	14,817	40	592,680
7)	Twin Turboprop: ≥ 12,500 TOGW	29,472	4	117,888
8)	Twin Turbojet Fan: ≤ 20,000 TOGW	18,024	16	288,384
9)	Twin Turbojet Fan: ≤ 20,000 TOGW	35,853	5	179,265
11)	Multi Turbojet Fan: ≥ 20,000 TOGW	56,940	5	284,700
12)	Piston-Rotary Wing	6,950	319	2,217,050
13)	Turbine-Rotary Wing	18,035	22	396,770
				173.3 mil
			Losses Incurred	112.6 mil
	Insurance Company and Supplier Gross Value-Added = GNP Contribution			60.7 mil

*No insurance data were available for categories 4, 5, and 10.

Sources: FAA, Selected Statistics United States General Aviation 1959-1976, DOT-FA77WA-4041 (January 1973).

National Aviation Underwriters, Inc.: "10K Report--1977" Securities and Exchange Commission.

AVEMCO: "Annual Report--1977".

Piper, R.R.: "A Study of Pricing Strategies at General Aviation Airports" Stanford University Ph. D. Disseration (1971) Appendix II.

the 65 percent loss ratio utilized is within the range for profitability indicated in the study by Piper cited in Exhibit 2-32. Piper also indicates that while any one company may experience very high or very low losses in a given year, the industry-wide loss ratio is probably between 55-75 percent. Third, the insurance estimates shown in Exhibits 2-32 and 2-33 do not include the insurance premiums paid by air taxi, flight instructors and aircraft rental operators. These estimates are subsumed in the analysis of those operators shown in the FBO section of this report, and were not included here to avoid double counting.

BANKING SERVICES

Banks, manufacturers, insurance companies, and leasing companies provide funds to general aviation users for the purchase (or use) of flight equipment. Interest payments made by GA users are inputs into the production of general aviation products and services and therefore are part of GNI. On the GNP side, the only contribution to current production made by banking services are those subsumed in the prices for air taxi, flight instruction, and aircraft rental service. These contributions are included in the contribution to GNP made by FBO's and are not separately identified in this section. All other uses of aircraft requiring the use of banking services are involved in either intermediate products or personal consumption, neither of which is counted as current production.[1] Thus, in the present section, only the GNI contribution of banking services are considered.

Exhibit 2-34 is a summary of the 1977 interest payments made by owners of general aviation aircraft. In order to derive these calculations, the following assumptions were made.

- on average, an airplane is resold every three years,
- all aircraft are financed,
- the terms of all loans are identical in any given investment year.

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[1] Before 1965, interest paid would have been part of consumption and GNP. But, the Commerce Department began excluding them in 1965 because such payments do not reflect current (as opposed to past) production.

Exhibit 2-34

SUMMARY OF 1977 INTEREST PAYMENTS MADE BY NON-PERSONAL OWNERS OF GA AIRCRAFT

Aircraft Type	Interest Paid ($ Millions)	Number of Aircraft
Single Engine, 1-3 Seats	48.40	51,886
Single Engine, 3 or More Seats	78.24	94,858
Twin Piston	105.46	20,156
Twin Turboprop <12,500 lbs.	47.31	1,849
Twin Turbprop >12,500 lbs.	13.36	263
Twin Turbojet <20,000 lbs.	49.34	975
Twin Turbojet >20,000 lbs.	62.62	548
Multi Turbojet > 20,000 lbs.	42.27	319
Piston Rotary	4.09	2,701
Turbine Rotary	9.06	1,164
TOTAL	$460.15	

Such assumptions lead to only approximate estimates of the interest paid by general aviation in 1977. The assumptions concerning the loan conditions, and the turnover rate of aircraft in the fleet, are based on average tendencies identified in the following tables. But perhaps the key assumption is that all aircraft are financed. Clearly, there are numerous occasions where flight equipment is either leased or bought outright. In the case of leasing, the lessee pays an implicit interest expense to the lessor which is probably not very much different from the interest payment he would make if the aircraft had been financed through a loan agreement. However, because there are occasions where aircraft are bought outright--the estimates in Exhibit 2-34 overstate the actual dollar volume of interest paid by general aviation users. Thus, the results in Exhibit 2-34 include some imputed interest which is simply the opportunity cost of the money utilized in the outright purchase of aircraft.

Exhibit 2-35 illustrates the methodology employed for making the calculations of interest payments in 1977. As can be seen from the exhibit, each type of general aviation aircraft was examined separately. Interest payments are generally a function of the age composition of the fleet, the assumed year of investment in the aircraft, and a total number of aircraft in the type category. The investment years were assumed according to the patterns shown in Exhibit 2-36. As can be seen, all aircraft produced in a given year are assumed to be purchased in one of three years: 1975,

Exhibit 2-35

METHOD TO DETERMINE THE INTEREST COMPONENT
OF THE GNI CONTRIBUTION OF GENERAL AVIATION

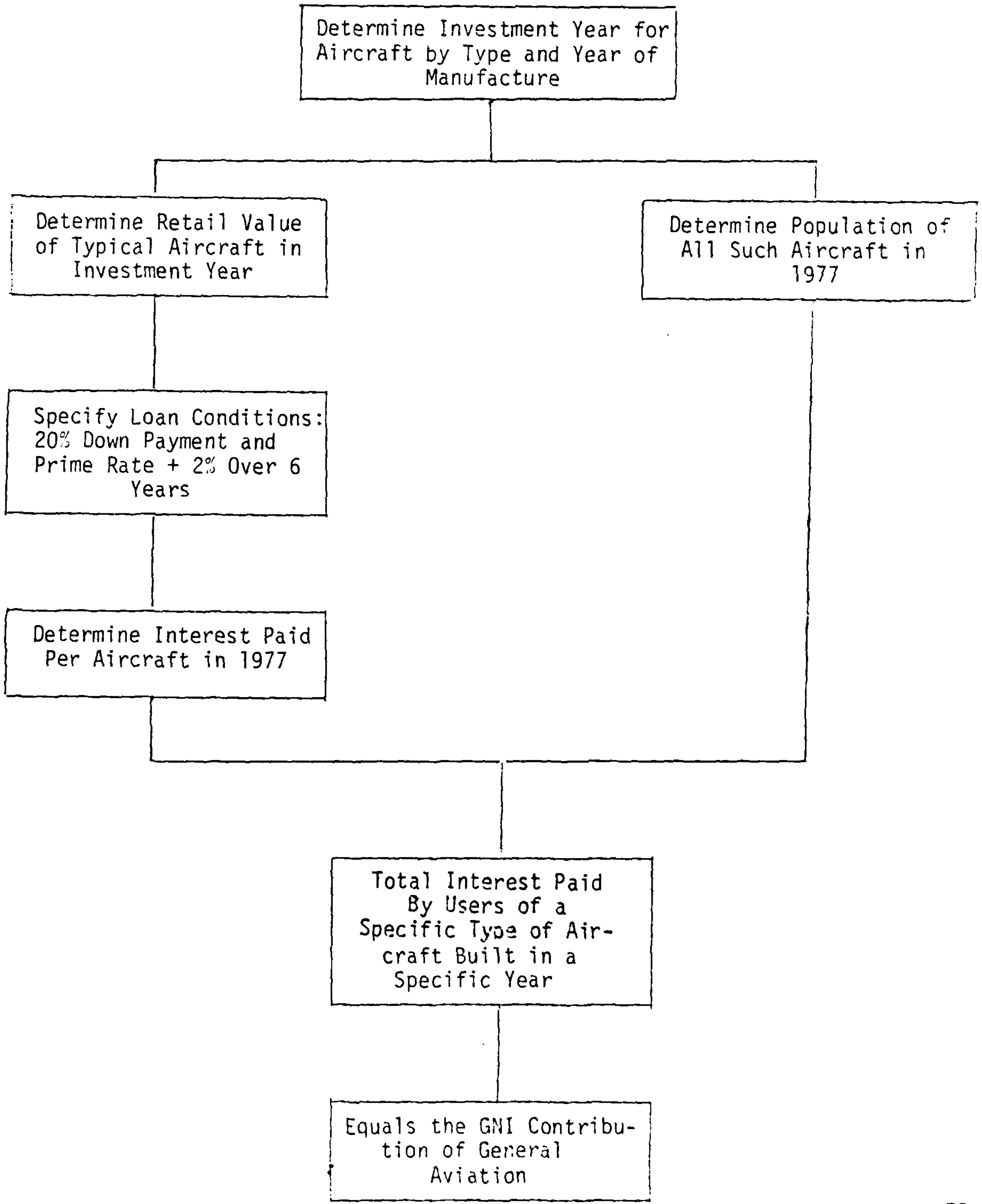

Exhibit 2-36

ASSUMED INVESTMENT YEAR FOR AIRCRAFT

Assumed Investment Year	ACTUAL YEAR OF MANUFACTURE																											
	77	76	75	74	73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50
1977	X			X			X			X			X			X			X			X			X			X
1976		X			X			X			X			X			X			X			X			X		
1975			X			X			X			X			X			X			X			X			X	

1976, or 1977. This follows directly from the assumption that the turnover rate of the fleet on average is three years.

Exhibit 2-37 is a sample calculation for single engine piston aircraft (+3 seats) manufactured in 1977. These aircraft are assumed to be purchased in 1977 at an average retail price of $44,627. The down payment is 20 percent and the interest rate is the prime rate, plus two percent. The loan is a conventional mortgage, declining principal, over a six-year period. Using these facts, the interest paid on this aircraft in 1977 is $3,024. There were a total of 3,907 such aircraft produced in 1977. As a result, $9.37 million in interest was paid by users of single engine piston (+3 seats) manufactured in 1977.

An example of the calculation of interest payments for aircraft manufactured before 1976 is shown in Exhibit 2-38. Available data indicate that 9,210 single engine piston aircraft (+3 seats) were produced and purchased domestically in the period 1970-1975. The remainder of Exhibit 2-38 shows the calculations needed to determine the average interest paid in 1977 for aircraft produced in the years 1970-1975. Notice that the retail value, down payments, interest rate, and interest paid per aircraft are a function of the assumed year of investment, together with the year of manufacture.

Interpretation of Results

As Exhibit 2-34 shows, the banking services industry received interest payments of $460.15 million in 1977 from users of general aviation aircraft. These interest payments were inputs into the

Exhibit 2-37

SAMPLE CALCULATION OF INTEREST PAYMENTS FOR AIRCRAFT MANUFACTURED IN 1977 OR 1976

Procedure (See Exhibit 2-36)	Characteristics	Sources
Aircraft Type and Year of Manufacture	1977 Single Engine Piston Aircraft, +3 Seats	-
Year of Investment	1977	Assumed
Retail Value	$44,627	FAA, Selected Statistics United States General Aviation 1959-1976
Loan Conditions	Down Payment: $8925 Interest Rate: 8.82% 6 Years, Conventional Mortgage	Based on: James Bullitt, "Present Status of Bank Financing of General Aviation Aircraft and the Future Prospects," Stonier Graduate School of Banking (1972); and in conversations with lenders and lessors.
Interest Paid in 1977 per Aircraft	$ 3,024	Calculated
Number of Such Aircraft	3,097	GAMA Production Statistics
Total Interest Paid	$9.37 Million	Calculated

Exhibit 2-38

SAMPLE CALCULATION OF INTEREST PAYMENTS FOR AIRCRAFT MANUFACTURED BEFORE 1976

	Single Engine Piston, 1-3 Seats						Sources
Aircraft Type and Year of Manufacture	1975	1974	1973	1972	1971	1970	
Year of Investment	1975	1977	1976	1975	1977	1976	Assumed, based on AOPO "Profile of Flying and Buying" (1978)
Retail Value	$24,156	$18,941	$19,916	$16,861	$15,272	$14,442	FAA, Selected Statistics U.S. General Aviation 1959-1976 (January 1978)
Down Payment	$ 5,031	$ 3,788	$ 3,983	$ 3,372	$ 3,054	$ 2,884	Based on: James Bullitt, "Present Status of Bank Financing of General Aviation Aircraft and the Future Prospects," Stonier Graduate School of Banking (1972); and conversations with lenders and lessors
Interest Rate	9.86%	8.82%	8.84%	9.86%	8.82%	8.84%	
Interest Paid Per Aircraft in 1977	$ 1,308	$ 1,283	$ 1,131	$ 877	$ 1,035	$ 819	Calculated
Average Interest Per Aircraft in 1977	$ 1,075						Calculated
Number of Such Aircraft	9,210						FAA, (Ibid.) and S.J. Vahovich, "General Aviation: Aircraft, Owner, and Utilization Characteristics," FAA-AVP-76-9 (November 1976)
							FAA, Ibid.
							Calculated
Total Interest Paid	$ 9.90 Million						Calculated

production of general aviation flight services and are therefore appropriately part of the gross national income of the United States. With the exception of air taxi, flight instruction, and aircraft rental, the other uses of general aviation aircraft are intermediate products in the production of other goods and services. For these other uses, then, there is no direct GNP contribution made by general aviation. The GNP contributions made in the production of air taxi, flight instruction, and aircraft rental services are subsumed in the estimates shown in the FBO section of this report.

PROFESSIONAL PILOT SERVICES BY OPERATORS OTHER THAN FBO'S

While the contribution to economic activity by pilots employed by FBO's has been examined previously, the services of professional pilots in executive transportation and aerial application have not. The services of Ag-pilots are inputs in the farm sector of the economy; these inputs are sold in the open market and are readily identifiable in the national accounts. However, executive pilots are employed by numerous industries and their output is subsumed in the economic activity of those industries. Therefore, in the case of executive pilots, it was necessary to create a "dummy" industry to identify this activity. One precedent for the creation of a dummy industry is in the national input/output tables for the United States developed by the U.S. Department of Commerce.

Executive Transportation

In order to capture its contribution to GNI and GNP, a dummy industry was created for executive transportation. The only activity of this industry is the payment of wages to pilots. The output of the industry--pilot services used in executive transportation--is an input into other industry production functions. The other inputs in the dummy industry are produced either by other GA industry segments--e.g., FBO's,[1] airports, aircraft manufacturers--or by

[1] Although some FBO functions are sometimes performed by flight departments of aircraft owners, no estimate could be made on this contribution to GNI.

other industries which serve the GA industry--e.g., petroleum producers, banks and insurance companies. Thus, the GNI contribution of the executive transportation industry is pilot wages. Because all of its output is an intermediate product, the GNP contribution of the dummy industry is zero.

Exhibit 2-39 shows the data and methods used to estimate wage payments to pilots. Essentially, the method allocates all pilot salaries to flight hours even though pilots normally perform other functions including overseeing maintenance, maintaining records for tax purposes, and maintaining flight proficiency. However, because these other functions are in support of the production of executive transportation, the real cost of a pilot (and his value added) is essentially his salary divided by the number of executive flight hours produced. Therefore, the salary per flight hour far outstrips the salary per hour worked during a year.

Agricultural Aviation

The same approach that was used to capture corporate pilot wages is repeated for agricultural pilots. Only the pilot wages make a unique contribution to GNI because other input payments are captured in the analysis of FBO's. All agricultural flying is an input into the production of farm (or other) products and therefore there is no GNP contribution attributable to this GA industry segment.

Exhibit 2-39

CALCULATION OF PILOT WAGES FOR EXECUTIVE TRANSPORTATION

(1) Aircraft Type	(2) Business/ Executive Hours[a]	(3) Business/ Executive Aircraft[a]	(4) Percent Executive Hours[b]	(5) Executive Hours	(6) Salary Per Flight Hour[d]	(7) Pilots Per Aircraft[d,e]	(8) Wages Paid ($ Millions)[f]
Single Engine	5,370,024	32,060	7.1	381,272	32	1	12.2
Twin/Multi-Engine	3,580,659	13,193	47.1	1,689,466	58.83	1	99.4
Turboprop	933,118	1,765	100	933,118	33.60	1.22	38.3
Turbojet	642,057	1,276	100	642,057	52.21	2.03	68.0
Turbine Helicopter	149,302	424	100	149,302	73.12	1	10.9
					Total Wages Paid		$228.8
					Fringe Benefits (at 30%)		68.6
					Contribution to GNI ($ Millions)		$297.4

[a]Federal Aviation Administration, Selected Statistics United States General Aviation 1959-1976 (January 1978).

[b]Battelle, "General Aviation Dynamics Model."

[c]Col. (2) X Col. (4).

[d]Business and Commercial Aviation, "B/CA Salary Survey: 1978" (September, 1978). Salaries are [illegible] of utilization rates.

[illegible] per aircraft are a weighted average within aircraft types.

[illegible] Col. (6) X Col. (7).

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THE RELATIONSHIP OF GENERAL AVIATION-ASSOCIATED PRODUCTS AND SE--ETC(U)
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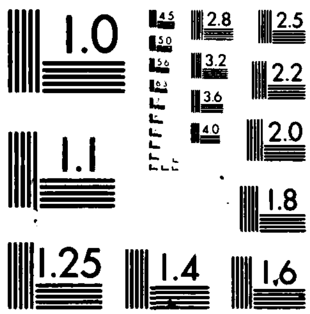

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

In 1977, there were approximately 2,447,000 hours of flight in the aerial application use category.[2] The average wage payment to pilots was $16.56 per hour.[3] Therefore, the total wages to Ag-pilots and the unique GNI contribution of aerial application in 1977 was $41.019 million.

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[2]ECON, Inc., The Benefits of Improved Technologies in Agricultural Aviation, prepared for NASA, Office of Aeronautics and Space Technology (July, 1977), p. 5.

[3]Gobetz and Assarabowski, "Study of Future World Markets for Agricultural Aircraft," Contract NAS1-14795, NASA (April, 1979), p. 86.

GOVERNMENT AIRPORT ENTERPRISES

According to the "National Airport System Plan 1978-1987,"[1] there were 13,830 airports in the United States in 1977. Of these, 6916 were closed to the public and accounted for only a small proportion of aviation activity. Of the remaining airports open to the public, 4265 were owned by various government entities. Only two of these publicly owned airports--Washington National and Dallas--are owned by the Federal Government. The economic activity generated by these two federal airports is included in the budget of the FAA and therefore they are considered in the following section on general government. Of the remaining 4263 publicly owned airports, 167 were considered hub airports, each of which accounted for at least .05 percent of the passengers enplaned by commercial carriers in the U.S. These airports as a group accounted for 95.8 percent of all domestic enplanements.

The remaining 4094 publicly owned and 2649 privately owned airports handle the majority of general aviation activity. Conceptually, it seems appropriate to allocate most or all of these activities to general aviation. Unfortunately, no data exist on the economic activity at privately owned public use airports. Furthermore, economic activities at these private airports are inextricably linked with FBO production and in fact many of the

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[1]FAA, "National Airport System Plan 1978-1987," (1977) p. 2.

airports are owned and operated by FBO's. Therefore, it is hypothesized that the majority of economic activity at private airports has already been captured in the analysis of FBO's, but, at present, there is no known method of testing this hypothesis short of performing a costly and time consuming survey which is beyond the scope of this project.

Data do exist, however, on the economic activity at publicly owned hub and non-hub airports. The Government Finances Division of the Bureau of the Census collects the following data from all airport authorities (or equivalent agencies) of city, state and local governments:

- Revenues (other than tax and intergovernmental transfers and refunds),
- Salaries and wages,
- All other direct expenditures for current operations,
- Capital outlays.

In terms of the national accounts, the GNI contribution of such airport enterprises includes compensation (including benefits) and current surplus (profit). All of the available data from the Census Bureau are summarized in Exhibit 2-40.

As can be seen from the footnote to Exhibit 2-40, there were some problems encountered in summarizing the data for the present study. The data are not readily available in a format which allows easy segregation into hub and non-hub classifications. In order to avoid the expense of auditing literally thousands of records,

Exhibit 2-40

REVENUE, EXPENSES, AND CAPITAL OUTLAY BY LOCAL, STATE, AND CITY GOVERNMENTS AND SPECIAL DISTRICTS AT U.S. AIRPORTS IN 1977

($ Millions)

	Current Operation					Capital Outlay
	Revenues (Airport Charges)	Salaries & Wages	Benefits[2]	All Other Direct Expenditures	Operating Profit	Construction and Purchase of Land, Equipment and Existing Structures
All Public Airports	1,254,125	328,178	47,586	372,972	505,389	559,461
Large Hub Airports	905,569	203,153	29,457	187,641	485,319	352,906
Medium Hub Airports[1]	154,853	43,289	6,277	51,838	53,448	67,761
Small Hub Airports[3]	132,057	21,505	3,118	25,746	81,688[4]	135,413[5]
All Others[6] (General Aviation Airports)	61,646	60,231	8,733	107,748	-115,066	

[1] Data was gathered for 30 of 39 medium hub airport sponsors. The data was extrapolated to include all medium hub airports.

[2] Benefits were calculated from salaries and wages by assuming a rate of (14.5). This rate was published by the Bureau of Labor Statistics, Department of Labor, and appears in Employee Compensation in the Private Non-Farm Economy, 1976. It is a summary average for employees in non-manufacturing industries.

[3] Data for small hub airports calculated by using ratios from S. Baumol, Airport Revenues and Expenses. Airport Economic Planning. Revenues for small hub airports averaged 35.2 percent of medium hub airports. Expenses averaged 20.5 percent of medium hubs.

[4] Calculated by subtracting current operating expenses from current revenues (did not use method described in note 2).

[5] This amount was spent on capital at small hub airports and the all other category. Any method of allocation would have been purely arbitrary.

[6] 4.24 percent of U.S. air carrier enplanements took place at these airports; the rest was general aviation.

Source: Dept. of Commerce, Bureau of Census, All U.S. Airports, 1977 census of governments data file. Dept. of Commerce, Bureau of Census, Large and Medium Hubs, individual airport sponsor identified and summed for each category.

the study team concentrated its efforts on developing reliable statistics on large and medium hub airports; data from the latter hub class were used to estimate economic activity at small hubs. The hub statistics were then subtracted from the data for all public airports to derive the estimates for the GA airports.

Exhibit 2-41 shows the GNI contribution (compensation plus current surplus) for public airports in 1977 attributable to GA. Notice that non-hub airports are operated at a deficit because they do not generate sufficient carrier passenger traffic to operate profitable concession activities. In effect, the $46.102 million deficit is a subsidy paid by non-Federal Governments to maintain ties to the national air transportation system. Also observe that the GA GNP contribution made at public airports--defined as final sales to the household sector--is approximated by multiplying the proportion of total GA flight hours due to personal use by the total retail sales. All other airport purchases are intermediate products. This treatment of GNP contribution differs from that for general government because there is market information for airport services which can be traced to the sectors of the economy.

Interpretation of Results

The GNI and GNP contributions shown in Exhibit 2-41 are for publicly owned airports only. There is a possibility that some of the economic activity at private airports, which has been assumed to be coincident with FBO activity, has not been captured.

Exhibit 2-41

GA GNI AND GNP CONTRIBUTIONS AT PUBLICLY OWNED AIRPORTS
($ Millions)

	Non-Hub Airports	Hub Airports**	Total
Salaries and Wages	60.231	40.221	100.452
Benefits	8.733	6.038	14.771
Current Surplus	(115.066)	98.839	(16.167)
GNI Contributions	(46.102)	145.088	99.056
Total Revenue	61.646	189.320	250.966
Percent to Household Sector*	42.0	42.0	-
GNP Contribution	25.891	79.514	105.405

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*(Personal hours + Personal Air Taxi, Rental and Instruction Hours) ÷ Total Hours. Statistics from FAA, Selected Statistics United States General Aviation 1959-1976 (January 1978); proportions for air taxi, rental and instruction hours are derived in the FBO chapter.

**Revenues and income were allocated based on estimated percentages of revenues accounted for by GA at hub airports. These percentages were: 12.7 percent for large hubs, 20.7 percent for medium hubs, and 32.0 percent for small hubs. See Aerospace Corporation, "Economics of Airport Operations," FAA, Office of Aviation Economics (1974).

On the other hand, much of the production attributable to public airports is sold to FBO's as intermediate products which would tend to overstate the GNP contribution attributable to GA activity at public airports. At present, there is no information available to test how serious these problems may be. Therefore, the GNI and GNP contributions are rough approximations.

Notice also that because national accounts conventions have been strictly adhered to, the true measures of economic activity at government airports are likely to be far higher than those shown in Exhibit 2-41. No account has been taken of the significant capital outlays made in the production of these airports' services. All such payments are treated as intermediate products in the national accounts. But, the size of these outlays is shown by airport size category in Exhibit 2-41 and total to over $1.1 billion in 1977.

GENERAL GOVERNMENT

The federal agency which provides the majority of services to GA is the FAA. For the most part, these services are provided to users at no direct cost; therefore, there is little market information available to evaluate their value. To remedy this lack of market information, government services are, by convention, valued at cost. All general government services are final products, so that GNI and GNP contributions are identical.

The cost of government services includes only wages and benefits paid to employees and current surplus (profits). For most FAA services, no current surplus exists. All other factor and non-factor payments are considered intermediate products in the national accounts. Thus, all payments associated with land and capital--interest, rent, and profits and depreciation--are excluded from both the GNI and GNP contributions of the FAA.

While other agencies of the Federal Government--especially the CAB[1]--do provide services to general aviation, the resources devoted to them are insignificant and therefore are ignored. Thus, the Federal Government's GA-related contribution to GNI and GNP is assumed to include only FAA expenditures.

The question of allocating FAA expenditures between GA and other users--air carriers and military--is an old and controversial

[1]All commuters in 1977 were Part 298 carriers which meant, among other things, that periodically they had to report certain traffic and fleet information to the CAB.

one. It is beyond the scope of this project to consider, much less resolve, all of the issues which pertain to this question. Nevertheless, a short summary of these issues will serve to clarify the methodology employed in this project.

The primary reason for a controversy concerning the allocation of FAA services to users is due to the fact that no market information exists for the services provided. If a market existed for the services and if the market were approximately competitive on both the demand and supply sides, the prices charged would equal marginal costs. Most current thinking[2] concerning the allocation question therefore reflects a need to approximate a competitive market by deriving marginal costs.

Several approaches for estimating marginal costs are employed in the literature. For instance, one can disaggregate FAA functions into appropriate categories and estimate marginal costs based on activity by user groups. Another approach entails constructing a model of the airway system in the absence of air carrier and military users. Still another approach is to define the GA allocation, based on aggregate expenditure and user activity statistics. The strengths and weaknesses of these alternative methods are detailed in the sources cited in footnote 2. A median estimate based on all three methods is employed in this study

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[2] See for example, Mitre Corporation, Airport and Airway System Cost Allocation, prepared for USDOT under Contract DOT-FA69NS-162 (September 1977); or John M. Rodgers, Financing the Airport and Airway System: Cost Allocation and Recovery, FAA-AVP-78-14 (November 1978).

which reflects the fact that the controversy concerning allocation is not yet resolved.

Before presenting the results, however, one issue concerning the applicability of the three methods to the present study must be resolved. All of the previous studies of allocation have entailed estimation of long-run marginal costs which include capital and other cost components which are fixed in the short run. The present study includes only wages and benefits in the value added of GA services provided by the FAA. Therefore, it is necessary to determine whether capital and other charges are proportional to wage payments in the determination of costs.

To test for the proportionality of factors, a short-run marginal cost function for en route traffic control was estimated from data provided in the Mitre study.[3] The regression results are shown in Exhibit 2-42. (The results are as satisfactory, from a statistical standpoint, as those shown in the Mitre Study.) Using the coefficient for general aviation activity, together with the number of GA flights indicates that $48.9 million of the $236.1 (20%) expended on operations (labor) at 19 en route centers was due to GA. Using the Mitre equation for long-run marginal costs (including capital and other charges), GA accounted for 19.0 percent of costs. It therefore appears that short-run marginal costs attributable to GA are proportional to long-run marginal costs.

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[3] Mitre, Op. Cit., p. C-3.

Exhibit 2-42

DERIVATIONS OF OPERATIONS (LABOR) COSTS FOR ENROUTE TRAFFIC CONTROL

$$OC = 90.44 + \underset{(6.66)}{12.40\ AC} + \underset{(2.73)}{8.36\ GA} + \underset{(4.32)}{11.36\ Mil} + \underset{(0.21)}{14.46\ Mileage}$$

$$\bar{R}^2 = .92$$

$$F = 50.77$$

OC = Operations (labor) costs

AC = Air carrier aircraft handled

GA = General aviation aircraft handled

Mil = Military Aircraft Handled

Mileage = Sum of low altitude and high altitude miles

Source of Data: Mitre Corporation, Airport and Airway System Cost Allocation, Report No. DOT-FA69-NS-162 for Federal Aviation Administration (September 1977), Table C-1, p. C-3.

Exhibits 2-43 and 2-44 show five aggregate and disaggregate methods to determine FAA compensation and benefits attributable to general aviation. Except for the minimum cost of service approach method (number 3), which is based on a model of the aviation system without air carrier and military movements, the allocations approaches yield similar results. Because the other four allocation methods (numbers 1, 2, 4, 5) are based on the current as opposed to a hypothetical system, they are probably more relevant to the present study. The range of differences of values for these four methods is about $31 million. The median value of $360.9 million is representative of these four methods.

Therefore, the GNI and GNP contributions due to FAA services to general aviation is estimated to be $360.9 million.

Exhibit 4-43

DISAGGREGATE ALLOCATION APPROACHES (1977 DOLLARS)

Budget Category	Total Compensation and Benefits ($000)	Allocated Share New Investment Marginal Cost (%)	Method 1 GA Allocation New Investment Marginal Cost ($000)	Allocated Share Baseline Costs (%)	Method 2 GA Allocation Baseline Costs ($000)
Operations	1,390,512	29.1	404,639	28.4	394,905
Facilities, Engineering and Development	5,011	0	0	0	0
Operations & Maintenance Metro DC Airports	28,444	0	0	0	0
Facilities and Equipment	55,764	31.2	17,398	32.45	18,095
Research, Engineering and Development	23,982	24.7	5,924	24.53	5,883
	1,503,713		427,961		418,883
Adjustment for air carrier training and government flight costs:			385,361		379,983

Sources: See Footnote 1

Exhibit 2-44

AGGREGATE ALLOCATION APPROACHES (1977 DOLLARS)

Method	Allocated Shares (%)	GA Allocation ($000)*
3) New Investment Marginal Cost	24.0	360,891
4) Minimum Cost of Service	13.0	195,483
5) Baseline Costs	23.57	354,425

*Based on total compensation and benefits of $1,503,713,000

Sources: See Footnote ?

CHAPTER 3

RESOURCE SAVINGS AND CONSUMER BENEFITS ATTRIBUTABLE TO THE USE OF GENERAL AVIATION AIRCRAFT

RESOURCE SAVINGS AND CONSUMER BENEFITS ATTRIBUTABLE TO GENERAL AVIATION

There are two distinct but related questions addressed in this chapter:

- o What is the value of the resource savings attributable to the use of general aviation aircraft in the production functions of other industries?
- o What is the value of the consumer benefits which attend the use of general aviation for recreational or other personal reasons?

Both of these questions relate directly to the issue of whether there are aggregate returns to the economy due to the use of general aviation aircraft. These returns (or losses) accrue to users either in the form of resource savings or consumer satisfaction. They are termed direct benefits because no returns other than those enjoyed by users are considered.

The approaches to this issue described below are akin to those employed in capital budgeting by a private firm except the application is to the entire economy. Using this analogy, the issue can be reduced to the following:

- o Given a pool of capital assets which cost a certain amount of money to acquire (on an annualized basis), maintain and operate, is there any net return to the economy from operating the assets?

This issue is addressed for the following uses of general aviation aircraft:

- business and executive transportation,
- agricultural aviation,
- the Gulf Coast helicopter industry,
- air taxi and aircraft rental operations,
- personal transportation.

The discussions of these uses of general aviation aircraft are self-contained. A final section in this chapter addresses the theoretical shortcomings of the methods used to estimate the direct benefits. Beyond these theoretical shortcomings, however, it should also be noted that there may be other, indirect benefits attributable to the use of GA aircraft. Such indirect benefits might include:

- The net change in national private investment due to general aviation.
- Cost savings due to economies of scale--e.g., expanded markets--attributable to general aviation.
- Increased output due to the stimulation of investment in social overhead capital.

While some or all of these indirect benefits may exist to some extent, their estimation has proven to be beyond the scope of this project, and in the absence of more information, is not possible.

Thus, in interpreting the results in this chapter, it must be remembered that only direct benefits are considered. There may be other, indirect benefits attributable to general aviation which are not covered in this study.

DIRECT BENEFITS: BUSINESS AND EXECUTIVE TRANSPORTATION

In certain circumstances, some businesses choose to transport their personnel via GA aircraft instead of by other modes of transportation. These aircraft are part of the production processes of these companies and, in theory, should be employed only in cases where they are available and are the most productive alternative means of transportation. Use of available aircraft can meet this productivity criterion only if:

- the costs of transportation are lower than other modes, and/or
- the value of time saved through use of the private aircraft justifies its use.

Both of these conditions must be considered in tandem to meet the productivity criterion. For example, use of a GA aircraft makes little sense if the value of time saved does not at least offset the cost of operation.

These two conditions--relative operating cost and value of time--are used in a simulation model which derives the net benefit (or loss) due to the use of general aviation aircraft for business or executive purposes.[1] The main purpose of the model is to evaluate the relative direct and time costs of using GA aircraft in lieu of commercial aviation. In addition, the relative costs

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[1] In executive use, a professional pilot is employed, whereas in business use, one of the passengers flys the airplane.

of automobile travel are considered. In general, the use of GA aircraft in lieu of an alternate mode is less expensive and therefore makes economic sense when the following is greater than zero:

Direct Cost of Alternate Model

MINUS

Direct Cost of GA

PLUS

Value of Time Used Via Alternate Mode

MINUS

Value of Time Used Via GA.

For example, suppose the cost of a commercial air ticket is $100 and the direct cost of a GA flight is $110; then if neither the GA flight nor the commercial flight has a time advantage, then clearly the commercial flight is preferred and the equation is negative--($100-$110). But, suppose in addition that the commercial flight requires a stopover at an intermediate point and that as a result the businessman could save an hour of productive time by using the GA aircraft. If the value of the businessman's time is more than $10, then it would make sense to fly in GA.

Of course, the aircraft must pay for itself to be a productive business asset. In order to conclude that resources are actually saved through business and executive use of GA aircraft, enough GA flights that are less expensive than travel via other modes must be made to offset the fixed annualized costs of the aircraft.

In summary, the simulation model developed to evaluate the resource savings due to the business and executive use of GA aircraft compares the relative direct and time costs of individual GA flights to other modes and then evaluate whether these benefits from all such flights are sufficient to offset the fixed costs of aircraft.

Direct Benefits--Conceptualization

The first step in evaluating the economic benefits of using GA aircraft for business and executive trips was to develop a computer simulation model to derive the economic benefit on a direct cost (before fixed costs) basis. These benefits are termed flight benefits in this report. The computer model evaluates flights for specific origin/destination pairs. Flights to New York City and Minneapolis were selected as being representative of typical business and executive trips. Cities included in the analysis were those in the Continental United States for which flights to New York City or Minneapolis were published in the Official Airline Guide (OAG). (A discussion of the selection of these city pairs and the implications for the analysis is included below.)

Exhibit 3-1 is a schematic rendering of the logic used in the GA flight benefit model. Desired departure times were approximated by using a distribution of departure times of GA business and executive flights published in the 1972 General Aviation Activity Survey.[2] These data show the percentage of total departures

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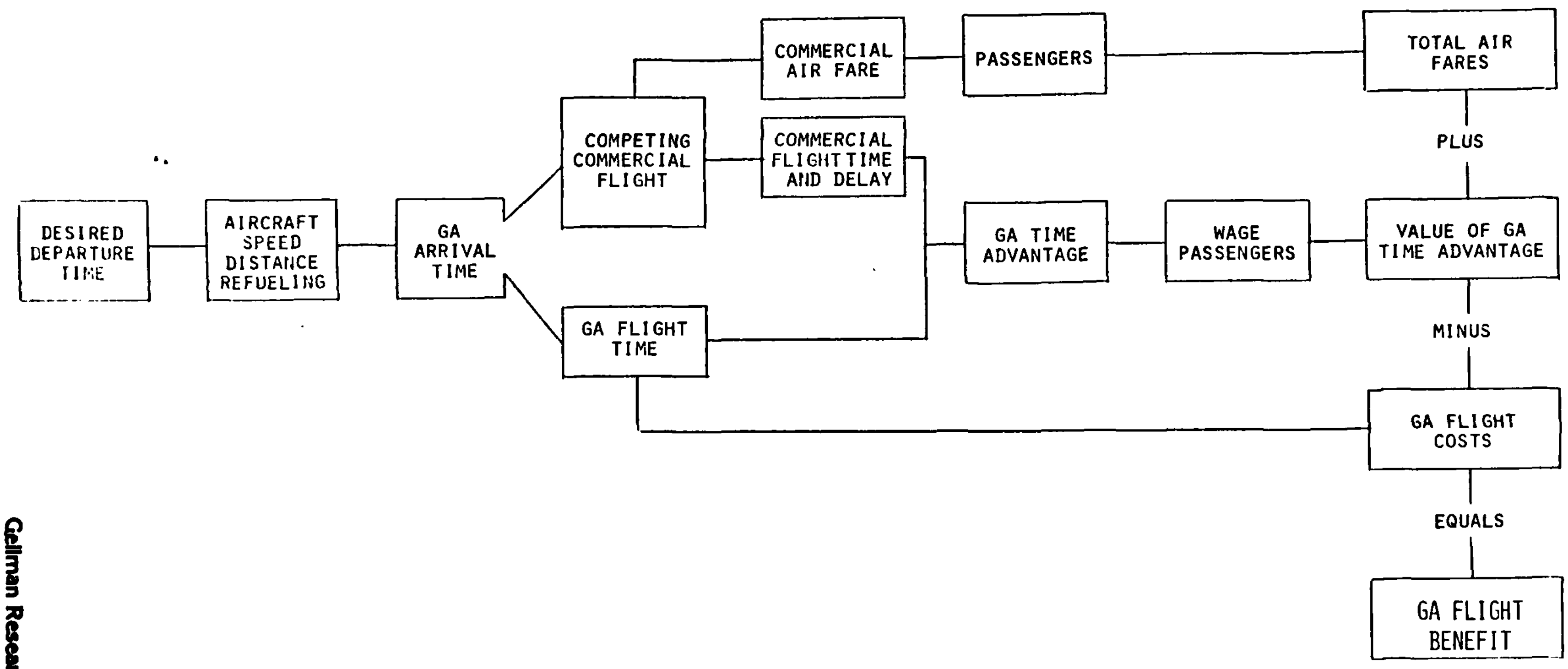
[2]FAA, "General Aviation Activity Survey," 1972 (July, 1974).

Exhibit 3-1

GA FLIGHT BENEFIT MODEL SCHEMATIC



occurring on an hourly basis between 6:00 and 22:00. Desired departure time was assumed to be on the half hour. For example, the first GA flights in all cases were assumed to occur at 6:30.

For each city pair, information on flight distance, typical aircraft speeds, and whether the aircraft would have to be refueled was combined to derive GA flight time and arrival time. By combining the information on GA flight time with the variable costs-per-hour of operating typical GA aircraft, GA flight costs could then be derived.

The next step in the process was to determine which airline flights compete with the GA flight. Because GA flight schedules are infinitely flexible, it is assumed that the GA arrival time is optimal from the standpoint of the traveler. Any deviation from the GA arrival time therefore is a delay which the traveler must endure if he switches to a commercial flight. The opportunity costs of this delay time should be evaluated at the traveler's wage rate which, in theory, is a monetary measure of his marginal productivity. In other words, the traveler incurs a delay which prevents him, at least in theory, from performing productive work.

Specifying the delay time depends critically on the flexibility of the traveler's schedule. Two sets of assumptions were used to approximate this flexibility. Under a set of assumptions termed "one-way delay," it is assumed that the traveler cannot arrive later than the GA arrival time. As a result, if he chooses to use commercial airlines instead of general aviation aircraft, he must arrive at his destination either at the GA arrival time or before it in order to meet his appointment schedule. Thus, under the "one-way delay" scenario, there is no flexibility in the traveler's schedule.[3]

The second set of scheduling assumptions is termed "two-way delays." Under this scenario, the traveler minimizes the commercial airline delay. He may therefore select that commercial flight which arrives at a time closest to the GA arrival time. Thus, his appointment schedule is assumed to be flexible which minimizes the delay penalties inherent in selecting the commercial airline.

Taken together, these two sets of scenarios provide estimates of the range of delays likely to be experienced by travelers who select commercial airlines instead of GA aviation. If appointment schedules are inflexible, the delays incurred will be approximated under the "one-way delay" scenario. If appointment schedules are flexible, the delays will be minimized under the "two-way delay" scenario.

Once the competitive commercial flight is specified, public airfares and the number of passengers assumed to be travelling can be used to derive the total airfares if commercial air is selected.

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[3] It is conceivable, of course, that there exists no commercial airline flight which meets these criteria on a given day. This would occur, for example, for early morning GA arrival times. In this case, the model assigns per-diem costs to the trip under the assumption that the traveler would have to arrive in a destination city by commercial airline the evening before in order to meet his fixed appointment the next day.

In order to determine the time savings (or losses) via GA, the following methods are employed. For each hour of the day, there is an expected commercial airline time plus delay. Similarly, there is a frequency distribution of the percentage of GA flights occurring in each hour of the day. Using these two sets of data, it is possible to derive the expected commercial airline time (including both flight time and delay) which is defined as a weighted average of the commercial airline time throughout the day for the specified city pair. By subtracting GA flight time from the expected commercial airline time, the GA time advantage is derived. Using information on the number and average wage of the passengers, it is then possible to derive the value of the GA time advantage, which is the value of the opportunity costs of selecting commercial air instead of general aviation.

The GA flight benefit is then: total airfares plus the value of GA time advantage, minus GA flight costs.

The GA flight benefit model also compares the benefits of using GA aircraft versus automobiles. Note that there are no schedules using either mode because they are equally flexible. The derivation of the GA flight benefit versus automobiles, however, is conceptually the same as the benefit versus commercial air. The GA flight costs are subtracted from the costs of operating the automobile (evaluated at 20¢ per mile). The value of the GA time advantage is determined by subtracting automobile travel time (assuming an average speed of 40 mph) from the GA flight time. The value of the GA time advantage is evaluated, using the same opportunity cost principles as those described above. As one might expect, the automobile competes successfully with general aviation aircraft only for relative short trips.

Summary

The GA flight benefit model derives the direct benefit of using general aviation aircraft in lieu of either commercial airline service or automobiles. These direct benefits are determined by first evaluating the relative costs of operating general aviation aircraft versus the cost of utilizing the other mode, and second, by evaluating the GA time advantage (or disadvantage) at the wage rate of the travelers. Using the wage rate to evaluate delays is justified because it is a measure of the opportunity cost (defined as the marginal productivity of the traveler) for time lost due to the selection of another mode.

Direct Benefits--Derivation

Exhibit 3-2 is a sample of results of the GA flight benefit model for twin-piston business flights from Pittsburgh to New York. (Some of the GA arrival times are not shown on this copy.) Notice that in this case, the commercial airline is the most effective competitor with the twin piston aircraft. The total cost of utilizing commercial airlines is \$188.47 under the one-way delay scenario and \$124.89 under the two-way scenario. The total airline costs under either scenarios are far below the total cost

Exhibit 3-2

FLIGHT BENEFITS OF BUSINESS USE OF TWIN-PISTON AIRCRAFT

PITTSBURGH TO NEW YORK

13. FROM DEPARTURE CITY PIT:

DISTANCE FROM PIT TO NEW YORK = 323 MILES
G.A. FLIGHT TIME = 93.62 MINUTES
TIME BY AUTOMOBILE = 546.78 MINUTES
AUTOMOBILE COST = 110.45 DOLLARS
G.A. COST = 103.38 DOLLARS
COMMERCIAL AIRLINE COST = 186.20 DOLLARS

ARRIVAL TIMES OF G.A. FLIGHTS DURING THE DAY (MILITARY TIME):

804	904	1004	1104	1204	1304	1404	1504	1604	1704	1804

METHOD 1: ONE-WAY DELAYS:

MINIMUM FLIGHT TIMES PLUS DELAY (IN MINUTES) FOR EACH HOUR OF THE DAY:

198.6	68.6	98.6	68.6	123.6	183.6	103.6	63.6	63.6	73.6	91.6

FLIGHT AND DELAY TIMES MULTIPLIED BY PERCENTAGE DISTRIBUTION:

1.39	1.24	5.23	5.90	10.63	16.71	8.81	5.41	5.47	6.85	7.97

EXPECTED COMMERCIAL AIRLINE TIME = 93.94 MINUTES
EXPECTED TIME SAVINGS OF G.A. VS. COMMERCIAL AIRLINE TRAVEL = .32 MINUTES
TIME SAVINGS OF COMMERCIAL AIRLINE VS. AUTOMOBILE TRAVEL = 452.84 MINUTES
NO. OF HOURS IN THE DAY CONTAINING NO AVAILABLE COMMERCIAL FLIGHTS = 1
SUM OF PERCENTAGES CORRESPONDING TO THESE HOURS = 0.007
TOTAL COMMERCIAL AIRLINE COST = 188.47 DOLLARS
TOTAL AUTOMOBILE COST = 1459.35 DOLLARS
NET G.A. BENEFIT = 85.10 DOLLARS

METHOD 2: TWO-WAY DELAYS:

MINIMUM FLIGHT TIMES PLUS DELAY (IN MINUTES) FOR EACH HOUR OF THE DAY:

117.4	68.6	98.6	66.4	123.6	68.4	66.4	63.6	63.6	66.4	66.4

FLIGHT AND DELAY TIMES MULTIPLIED BY PERCENTAGE DISTRIBUTION:

.82	1.24	5.23	5.71	10.63	6.22	5.64	5.41	5.47	6.17	5.77

EXPECTED COMMERCIAL AIRLINE TIME = 73.03 MINUTES
EXPECTED TIME SAVINGS OF G.A. VS. COMMERCIAL AIRLINE TRAVEL = -20.60 MINUTES
TIME SAVINGS OF COMMERCIAL AIRLINE VS. AUTOMOBILE TRAVEL = 473.75 MINUTES
TOTAL COMMERCIAL AIRLINE COST = 124.39 DOLLARS
TOTAL AUTOMOBILE COST = 1459.35 DOLLARS
NET G.A. BENEFIT = 21.52 DOLLARS

(including delay costs) of utilizing automobiles ($1,459.35). Thus, the net GA benefit is determined by subtracting the GA cost ($103.38) from the total commercial airline cost. In this case, under the "one-way delay," inflexible schedule scenario, there is a net GA flight benefit of $85.10, while under the "two-way delay," flexible schedule, scenario, the net GA flight benefit is $21.52.

Deriving Adjusted Flight Benefits

By selecting general aviation aircraft for business-related trips, travelers can potentially derive two additional benefits. First, because there are more airports in the country which are capable of serving general aviation aircraft as opposed to commercial aircraft, the average GA user saves ground-commuting time both at the origin and the destination of his trip. This time advantage has been termed the "ground transportation advantage of GA usage" (GTA). It accrues to all business and executive flyers.

The second benefit of selecting GA aircraft for alternative modes accrues only to executive flights. This benefit has been termed "on-site airport time advantage of executive flying" (OATE) and is described more fully below.

Deriving the Ground Transportation Advantage of GA Usage (GTA)

GA users are on average closer to an airport which can accommodate their aircraft than an airline passenger is to a commercial airport. This is true because there are 753 domestic air carrier and commuter airports[4] in the Continental U.S. but thousands of GA airports capable of accommodating aircraft of different sizes. Measuring how much closer GA users are to their airport than commercial flyers are to theirs would be a tedious task. A close approximation can be obtained, however, by making some simplifying assumptions.

Assume that the 3,022,260 square mile land mass of the Continental U.S. is approximated by a square, so that the side of the square is 1,738 miles. If the 753 air carrier and commuter airports are evenly distributed over the land mass, there are 27 rows and 27 columns of airports in the square. This implies that the average distance between adjacent airports is 64 miles.

To determine how far away the average traveler is from the closest airport, assume that all locations on the map are equally likely. Now consider the possible airports in the traveler's vicinity. Five of the airports are shown in Exhibit 3-3A. These five form four isosceles triangles with sides of 64 miles (see Exhibit 3-3B). The point most distant from any airport within these triangles is the centroid (C) shown in Exhibit 3-3C. No other point is further from an airport than point C. Thus, no traveler can be further from an airport, under the above assumptions, than the distance CA, which in turn is equal to CB and CE. On average, a given traveler will be one-half the distance CA from an airport providing either scheduled or commuter service.

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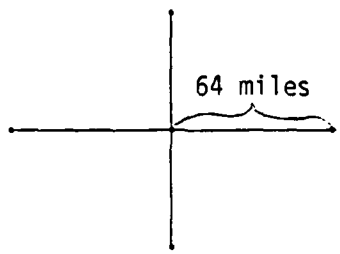
[4]FAA, National Airport System Plan (1978), p. iii.

Exhibit 3-3

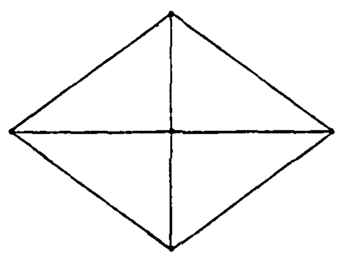
DISTANCE CALCULATIONS

Figure 3-3A:



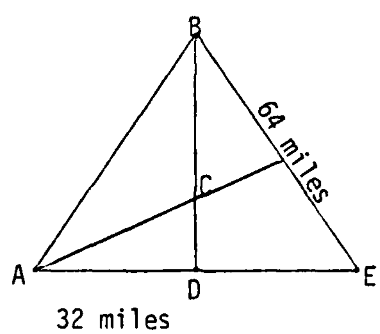
5 airports, each is 64 miles to nearest airport

Figure 3-3B:



5 airports form 4 isocycles triangles with 64 mile sides

Figure 3-3C:



The point most distant from any airport within a *triangle is the Centroid* (C). The average distance from any point within the triangle is one-half the distance from the Centroid (AC).

In order to calculate CA, notice the following. The centroid is the intersection of the three medians of the triangle in Exhibit 3-3C. It can be shown that the distance CD is 1/3 BD. Using the Pythagorean theorem for right triangles (ABD) the distance BD is given by:

(1) $64 = (32)^2 + (BD)^2$

$BD = 55.4$ miles

Because CD is equal to 1/3 BD, CD equals 18.5 miles. The distance CA therefore becomes:

(2) $CA = (32)^2 + (18.5)^2$

$CA = 40$ miles

Thus, on average, a given traveler is 20 miles from an airport providing either scheduled or commuter service.

Because there are many more airports which can accommodate general aviation aircraft, the average distance a GA traveler must traverse is much shorter. Exhibit 3-4 shows the number of airports which can accommodate each type of GA aircraft.

Repeating the same methodology described above yields estimates of average distances of travelers from airports which can accommodate GA aircraft. These estimates are shown for the four aircraft types in column (4) of Exhibit 3-5. Using these estimates, it is possible to value the travel time advantage of using airports which accommodate GA aircraft versus using only commercial or commuter airports. This advantage includes:

- The value of time of passengers.
- The savings in auto costs.

Exhibit 3-4

NASP AIRPORTS UTILIZED BY AIRCRAFT TYPES

				General Aviation Airports					
	Air Carrier Airports (620)	Commuter Airports (133)	Reliever Airports (147)	Basic Utility Airports[1] (1392)	General Utility Airports[2] (542)	Basic Transport Airports[3] (255)	General Transport Airports[4] (20)	Other Airports[5] (20)	Total Airports Available to Aircraft Type
Single-Engine Piston Aircraft	X	X	X	X	X	X	X		3,117
Twin Piston Aircraft	X	X	X	.5X	X	X	X		2,421
Turboprop Aircraft	X	X	X	.5X	X	X	X		2,421
Turbojets	X	X	X		.5X	X	X		1,454

[1] Basic Utility Airports accommodate most singles and many smaller twins.

[2] General Utility Airports accommodate all GA aircraft under 12,500 lbs.

[3] Basic Transport Airports accommodate large jets up to 60,000 lbs.

[4] General Transport Airports accommodate aircraft up to 175,000 lbs.

[5] Other Airports include heliports, STOL ports, seaplane basis.

Exhibit 3-5

GROUND TRANSPORTATION ADVANTAGE OF GENERAL AVIATION (GTA)

			MILES			GA SAVINGS CALCULATIONS							
	Total Airports Available to Aircraft Type	Number of Rows and Columns of Airports Evenly Distributed	Average Distance between Adjacent Airports	Average Distance of Traveller from GA Airport	Average Distance of Travellers from Commercial or Commuter Airport	Ground Distance Advantage of GA Airports	Auto Savings @ 20¢ per mile ($)	Traveller Time Advantage @ 40 MPH (Minutes)	Number of Passengers	Value of Time Per Minute	Value of Time Advantage	GTA Auto Savings Plus Time Advantage	GTA Per Flight
Single Engine Piston	3117	56	31	9.0	20	11	2.20	16.5	1.5* 2.4**	0.38 0.55	9.41 21.78	11.61 23.98	23.22 47.96
Twin Piston Aircraft	2421	50	35	10.1	20	9.9	1.98	14.9	3.8	.78	44.16	46.14	92.28
T[illegible] Aircraft	2421	50	35	10.1	20	9.9	1.98	14.9	5.7	.78	66.24	68.22	136.44
[illegible] Aircraft	[illegible]	38	46	13.3	20	6.7	1.34	10.1	5.4	.78	42.54	43.88	87.76
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)

*1.5 passengers in aircraft with three or fewer seats.

**2.4 passengers in aircraft with more than three seats.

In Exhibit 3-5, auto savings is derived by subtracting column (4)--average distance from GA airports--from column (5)--average distance from commercial and commuter airports and multiplying the difference by 20¢ per mile. This is a conservative estimate because it assumes all passengers arrive in one car.

The value of the time advantage is derived by multiplying column (8)--additional time to travel to the commercial/commuter airport--by column (9)--number of passengers--and column (10)--the value of time per passengers per minute.

In column 12, auto savings and the value of the time advantage are added to derive the Ground Transportation Advantage of GA Usage (GTA). It should be noted that these GTA estimates are for one city in a city-pair. Thus, GTA should be doubled for each GA flight (see column 13 of Exhibit 3-5).

Interpretation of Results--The estimates of GTA are added to the flight benefits (derived in the computer model) under the assumptions that GA users (1) always choose to land at the closest airport to their ultimate destination and (2) always choose as a base the closest airport to their place of business and/or home. Neither of these assumptions is likely to hold in all cases. Landing fees, shelter rentals and congestion at commercial airports may preclude their use by some GA users. However, this tendency is offset by two factors. First, business and executive users are less likely to be sensitive to landing fees and shelter rentals than personal users because all expenses are tax deductible.

At the same time, the fact that business and executive users own GA aircraft indicates that they are sensitive to the perceived time savings due to the use of these aircraft. Second, we have excluded from the analysis 1,728 airports with paved runways[5] that are not included in the National Airport System Plan. Exclusion of these airports reduces the estimates of GTA significantly, thereby at least partially offsetting any bias due to the assumption that GA business flyers always choose to operate to and from the closest airport capable of accommodating their aircraft.

On-Site Airport Time Advantage of Executive Flying (OATE)

One of the advantages of executive flying is that passengers avoid the ground and terminal congestion (and delays) which accompany commercial flying. Executive passengers generally avoid waiting: (1) to access the terminal from the parking lot; (2) to check in baggage and purchase tickets; (3) to clear security. Additionally, they avoid long walks along concourses to the gate areas. Furthermore, executive passengers have their aircraft on-call and waiting for them. They therefore avoid having to accommodate their schedules to flight schedules.

In contrast, business flyers must perform their own flight checks, determine weather conditions, park or store their aircraft, etc. They therefore save little or no time at the airport when compared to commercial flyers.

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[5] NBAA, NBAA Business Flying, 1976, Section 1.

Thus, executive flyers have a unique time advantage over both business flyers and commercial flyers. Measuring this time advantage, however, is difficult because air travelers--whether via commercial air or general aviation--experience different delays at different airports depending on specific circumstances. In order to measure the on-site time advantage of executive flying (OATE), we have focused on a single measure of delay at airports--on-line connect time published in the Official Airline Guide (OAG). On-line connect time defines the time a passenger (or scheduling agent) should allow to leave one flight and board another flight on the same airline. Because the same airline is involved in both flights, on-line connect time really is a measure of the time required to walk between gates (usually on the same concourse) and check-in on a new flight. It does not measure any other time spent in the terminal or on the ground side--e.g., security checks, baggage claim or check-in, parking delays, etc. Therefore, on-line connect time tends to underestimate the true on-site airport time advantage of executive flying (OATE).

For the 382 connections published for airports in the continental U.S., the average on-line connect time is 17 minutes. This is used in Exhibit 3-6 to derive OATE by GA aircraft type. OATE is simply on-line connect time multiplied by the number of passengers, and by their average wage rate. Notice that OATE applies on each end of the flight, so that per flight OATE is twice the estimate in column (4) of Exhibit 3-6.

Exhibit 3-6

ON-SITE AIRPORT TIME ADVANTAGE OF EXECUTIVE FLYING (OATE)

Aircraft Type	(1) Average OAG On-Line Connect Time (Minutes)*	(2) Number of Passengers	(3) Wage Per Minute	(4) OATE	(5) Per Flight Data
Single-Engine Piston	17	2.4	.55	22.44	44.88
Twin Piston	17	3.8	.78	50.39	100.78
Turboprop	17	5.7	.78	75.58	151.16
Turbojet	17	5.4	.78	71.60	143.21

*OAG, "Minimum Connecting Times" (September 1, 1977), pp. 27-31.

Adjusted GA Flight Benefits

For each business flight, adjusted GA flight benefits is GA flight benefits plus GTA (Ground Transportation Advantage of GA Usage). For each executive flight, the adjusted benefit includes the same variables plus OATE (On-site Airport Time Advantage of Executive Flying).

Summing Results from Different City Pairs

The GA flight benefit model derives flight benefits for each city pair. The city pairs are segregated into distance blocks. Using national averages for the percent of flights within, each distance block,[6] it is possible to derive the average weighted flight distance for each aircraft type. This information, together with FAA data on hours flown by use and aircraft type, and the typical speed for each aircraft type, was used to derive the total number of business and executive flights, using the following formula:

$$\text{Flights} = \frac{(\text{Hours}) \times (\text{Speed})}{\text{Average Weighted Flight Distance}}$$

Multiplying total flights by the appropriate mileage block frequency yields the number of flights in each distance bracket.

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[6]For single piston aircraft, data were employed from an FAA study entitled, "General Aviation: Aircraft, Owner, and Utilization Characteristics," by Stephen Vahovich. This data is broken down into 100-mile increments. For the other aircraft types, sample sizes in the Vahovich data base were deemed to be insufficient. The study team, therefore, employed data from a 1974 survey conducted by National Business Aircraft Association.

The GA benefit model derives the average GA flight benefit for each mileage category. Multiplying these average benefits by the number of flights within the distance category results in an estimate of the total GA flight benefits for each distance category. Summing these GA flight benefits over all mileage blocks results in an estimate of total GA flight benefits.

This method of summing up GA flight benefits implicitly assumes that all city-pairs <u>within</u> a mileage bracket are equally traveled. It would be pure accident if this were the case in the real world. However, to our knowledge there is no available information on specific business and executive itineraries which could be used to develop an alternative weighting scheme to derive total GA flight benefits.

Once the total GA flight benefits for all distance categories are summed, the adjusted GA flight benefits are derived by adding in GTA and OATE (as appropriate) weighted by the total number of flights. Thus, adjusted GA flight benefits include the benefits due to both the air and ground portions of a trip.

Deriving Net GA Benefits

The measure of adjusted GA flight benefits is the dollar value of resource savings due to the use of general aviation aircraft before fixed costs. In the present study, however, we are concerned with the long-run implications of the absence of general aviation. That is, the question to be answered is: What is the net return to users of business and executive aircraft after investment and all other expenses? Thus, the net GA benefit is: adjusted GA flight benefits minus fixed costs. Essentially, net GA benefit is the profit (including the value of delays avoided) due to the use of general aviation business and executive aircraft.

Results

This section presents the results of the runs of the GA flight benefit model adjusted for ground and airport time advantages and for fixed costs. The specific assumptions utilized in the analysis are shown in Exhibit 3-7, together with the sources of the data. All of the assumptions are based upon average characteristics of general aviation flights. As such, they represent typical utilization of general aviation aircraft, but may not reflect any one company's experience.

Before presenting the results of the analysis, a few comments concerning the assumptions are appropriate in order to aid the reader in the understanding of the derivations. Passenger income per hour is based on a 1975 FAA survey. These figures have been adjusted for inflation and also for fringe benefits. The speed of the aircraft is not the cruising speed, but rather the average realized speed over a typical flight distance as published in the FAA survey cited. The cruising range of the aircraft is the distance an aircraft can fly before refueling if the pilot allows a one-hour fuel reserve. These cruise ranges are for typical

Exhibit 3-7

ASSUMPTIONS FOR PASSENGER AND AIRCRAFT IN BUSINESS AND EXECUTIVE USE

Aircraft Type	Passenger Income Per Hour[1]	Speed (MPH)[2]	Cruise Range[4]	Variable Cost Per Hour[5] (1977)	Annual Fixed Costs[5] (1977)	Variable Cost Per Hour With Pilot (1977)[6]	Average No. of Passengers[2]
Single Engine 1-3 Seats	23	107	518	15.74	7673	NA	1.5
Single Engine 4+ Seats	33	145	680	21.33	10207	53.33	2.4
Twin Piston	47	207	1090	66.25	39648	125.08	3.8
Turboprop	47	252	993	174.5	123276	215.50	5.7
Turbojet	47	415	1774	630.1	179116	736	5.4
Rotary Piston	33	90[3]	NA	33.82	16496	NA	2.9
Rotary Turbine	47	125[3]	NA	71.16	44231	144.28	2.9

[1] S. Vahovich, General Aviation Aircraft Owner and Utilization Characteristics (FAA)

[2] FAA, 1975 General Aviation Activity Survey

[3] Lloyds, "Aircraft Types and Prices"

[4] GAMA, "General Aviation Aircraft"

[5] FAA, "General Aviation Selected Statistics"

[6] Pilot Costs, Business and Commercial Aviation, "1977 Wage and Salary Survey"

aircraft within each aircraft category. The variable and fixed costs of operation are also for typical aircraft within each aircraft category. There may be wide variations in these costs for certain of the aircraft in a category, especially for turboprops and turbojets. The pilot costs for executive transportation were derived by taking typical pilots salaries, including fringe benefits, and dividing them by flight hours accrued in the transportation of executives (as opposed to flight hours for other purposes, including training). The number of passengers is an average figure derived from the FAA source cited.

The results of the analysis based on flights to New York City and Minneapolis are shown in Exhibits 3-8 and 3-9. Of particular interest are the results for small single-engine piston and turbojet aircraft which indicate a negative net GA benefit. These negative results might be expected for the following reasons. For small single-engine piston aircraft, businessmen are no doubt deriving some consumption benefits from the utilization of their own aircraft. Because the negative benefits are relatively small in this category, one might surmise that these consumption benefits more than offset the loss of productivity indicated. For turbojets, the results are somewhat harder to explain. Negative benefits might be due to the fact that the average income figures assumed are too low for executives utilizing these aircraft; however, no other income figures were available to verify this hypothesis.

Exhibit 3-8

SUMMARY OF NET BENEFITS (1977) BASED ON NYC

Aircraft Type	Use	Net Benefits ($ Millions) 1-Way Scenario (Inflexible Appointment)	Net Benefits ($ Millions) 2-Way Scenario (Flexible Appointment)
Single Engine Piston <3 Seats	Business	-16.6	-19.6
Single Engine Piston >3 Seats	Business	156.77	41.64
Single Engine Piston >3 Seats	Executive	9.71	1.05
Twin Piston	Business	404.77	236.51
Twin Piston	Executive	373.03	227.77
Turboprop	Executive	407.94	271.32
Turbojet	Executive	-131.65	-265.52
Total Fixed Wing ($ Millions)		1203.97	493.23
Piston Helicopter	Business	4.36	4.36
Turbine Helicopter	Executive	6.50	6.50
Total ($ Millions)		1214.83	504.09

Average Net Benefits ($ Millions) = 859.46

Exhibit 3-9

SUMMARY OF NET BENEFITS (1977)
BASED ON MINNEAPOLIS

Aircraft Type	Use	Net Benefits ($ Millions) 1-Way Delay Scenario (Inflexible Appointment)	Net Benefits ($ Millions) 2-Way Delay Scenario (Flexible Appointment)
Single Engine, <3 Seats	Business	-11.86	-15.31
Single Engine >3 Seats	Business	285.07	154.62
Single Engine >3 Seats	Executive	18.85	9.10
Twin Piston	Business	528.46	327.74
Twin Piston	Executive	489.47	312.35
Turboprop	Executive	511.68	349.37
Turbojet	Executive	1.58	-135.69
Total Fixed Wing ($ Millions)		1823.25	1002.18
Piston Helicopter	Business	4.36	4.36
Turbine Helicopter	Executive	6.50	6.50
Total ($ Millions)		1834.11	1013.04

Average Net Benefits ($ Millions) = 1423.58

Another factor not taken into account in the analysis is the intangible benefits which might particularly accrue to executive transportation. These intangible benefits include:

- competitive advantage of GA users versus non-users,
- scale economies which may result from market extensions made possible by general aviation,
- lower input costs due to the location of plant and other facilities in remote areas,
- competitive advantages in recruiting key executive personnel.

Other observers of the value of general aviation flights in a business context have sometimes hypothesized that wage rates do not accurately reflect marginal productivity of executives. For example, some analysts have hypothesized that executive productivity is reflected in the total value of a company's output which these executives supervise. Such an hypothesis seems spurious for several reasons. First, this necessarily implies that executives are exploited by their firms. It seems very unlikely that executives face monopolist purchasers for their personal services which would reduce wage payments to levels below marginal productivity. One might just as forcefully make the argument that executives may have monopoly power in negotiating wage rates for their services. The mere existence of an entire consulting industry devoted to providing corporate clients with current information on executive compensation packages would seem to indicate that there is a scarcity of top echelon management talent. Second, it seems very unlikely that, in the absence of a particular person or job category, all production supervised by a particular executive would cease to exist. While this may be true for some smaller firms where critical human capital is embodied in individuals, such would appear not to be the case for large corporations were expertise is spread across thousands of management employees. Third, the results in Exhibits 3-8 and 3-9 show that there are significant resource savings in the use of other aircraft. Unless it can be shown that there are some special circumstances with regard to turbojet use, there appears to be no good reason for assuming that the wage rates assumed are too low.

The greatest resource savings occur in the use of twins and turboprops. These aircraft have significant performance advantages compared to single-engine aircraft and therefore are better able to compete directly with commercial airlines, especially in markets involving relatively small communities. These aircraft also do not suffer from the extremely high operating and fixed costs which are experienced in the use of turbojet aircraft.

It should also be noted that there are significant differences in the net benefits depending upon whether appointments are assumed to be inflexible or flexible. As would be expected, flexible appointment schedules result in smaller net GA benefits because the traveler can minimize his delay costs when selecting another mode. In contrast, under the inflexible appointment scenario, the traveler must arrive at his destination at the same time or before the general aviation aircraft would arrive. This inflexibility reduces the number of commercial airline flights which he could feasibly select as alternatives to general aviation, which in turn reduces the competitiveness of commercial air *vis-à-vis*, general aviation. Of course, there are no observations concerning the flexibility of traveler's schedules. An average estimate of net benefits is provided in both exhibits which would reflect a resource savings if half of the appointments were flexible, while the other half were inflexible.

In comparing Exhibits 3-8 and 3-9, it becomes readily apparent that the net GA benefits are consistently higher for the model runs based on Minneapolis. This is to be expected for several reasons. Air service to New York City is far more frequent because of New York's size and prominence in the economy, its importance as an international hub, the number of large firms within the tri-state New York area, and the communities of interest among all of the cities on the East Coast of the United States. In contrast, Minneapolis is a relatively isolated, medium-sized city, with a much smaller economic base.

New York was deliberately selected for analysis for all of the above-mentioned reasons. Runs of the model, based on New York, probably yield results which are much closer to minimum estimates of net GA benefits than for any other city in the United States. The runs of the model based on Minneapolis tend to verify this hypothesis. Only additional runs of the flight benefit model (which were beyond the budgetary resources of this project) would finally verify the hypothesis. However, based upon the evidence available, a conservative estimate of the range of resource savings due to the business and executive use of general aviation aircraft would be between $500 million and $1200 million.

Specific information of the derivation of net GA benefits for each aircraft type are shown in exhibits contained in Appendix A at the end of this chapter.

<u>Helicopters: A Special Case</u>

The flight benefit model was not used to analyze the resource savings due to the executive or business use of helicopters. Although some helicopters are used for intercity travel, their primary function is to ferry passengers between points which are relatively inaccessible to other aircraft. In addition, typical helicopter trips are shorter than other general aviation flights. Thus, helicopters primarily compete with automobiles and therefore there was no reason to examine their competition with commercial air in the context of the GA flight benefit model.

Exhibits 3-10 and 3-11 show the derivation of net GA benefits due to the use of piston and turbine helicopters, respectively. The only real difference between the derivations shown in these two exhibits and the derivations for other GA aircraft is that helicopter performance was examined in the context of average flight distances instead of for specific city pairs. In addition,

Exhibit 3-10

DERIVATION OF NET BENEFITS OF BUSINESS USE OF PISTON HELICOPTERS

Exhibit 7A: Piston Helicopter Performance and Variable Costs

Miles	Flights	Average Time (Hours)	Variable Cost Per Hour	Variable Costs All Flights (Millions)
0-100	146012	.55	33.82	2.716
100-250	16766	1.94	33.82	1.100
		Total Helicopter Variable Cost:		3.816

Exhibit 7B: Auto Performance and Costs

Miles	Trips	Average Time (Hours)	Cost of Average Trip	Cost All Trips (Millions)
0-100	146012	1.25	10.00	1.460
100-250	16766	4.37	35.00	.587
			Total Auto Cost:	2.047

Exhibit 7C: GA (Helicopter Time Savings)

Miles	Auto Time Minus Helicopter Time (Hours)	Value of Time Savings Per Flight	Flights	Value of Time Saved All Flights
0-100	.7	66.99	146012	9.781
100-250	2.43	232.55	16766	3.899
		Total Value of Time Saved:		13.680

Exhibit 7D: Derivation of Net GA Benefit

(Total Auto Cost) + (Total Value of Time Saved) - (Total Helicopter Variable Cost) - (Helicopter Fixed Costs)

(2.047) + (13.680) - (3.816) - (7.555)

Net GA Benefit = 4.336 Million

Exhibit 3-11

DERIVATION OF NET BENEFITS OF EXECUTIVE USE OF TURBINE HELICOPTERS

Exhibit 8A: Turbine Helicopter Performance and Variable Cost

Miles	Flights	Average Time (Hours)	Variable Cost Per Hour	Variable Costs All Flights (Millions)
0-100	266144	.4	144.28	15.360
100-250	30561	1.4	144.28	6.173
		Total Helicopter Variable Cost :		21.533

Exhibit 8B: Auto Performance and Costs

Miles	Trips	Average Time (Hours)	Cost of Average Trip	Cost All Trips (Millions)
0-100	266144	1.25	10.00	2.661
100-250	30561	4.37	35.00	1.070
			Total Auto Cost :	3.731

Exhibit 8C: GA (Helicopter) Time Savings

Miles	Auto Time Minus Helicopter Time (Hours)	Value of Time Savings Per Flight	Flights	Value of Time Saved All Flights
0-100	.7	115.86	266144	30.834
100-250	2.97	404.81	30561	12.371
		Total Value of Time Saved :		43.205

Exhibit 8D: Derivation of Net GA Benefit

(Total Auto Cost)	+	(Total Value of Time Saved)	-	(Total Helicopter Variable Cost)	-	(Helicopter Fixed Costs)
(3.731)	+	(43.205)	-	(21.533)	-	18.754

Net GA Benefit = 6.650 Million

no ground or airport time advantages are shown in Exhibits 3-10 or 3-11 because no such advantage exists when comparing helicopters to automobiles.

DIRECT BENEFITS: AGRICULTURAL AVIATION

Introduction

The same method of estimating direct benefits is employed here as in other GA use categories; that is, the cost of aerial application by GA is estimated and then compared to the cost incurred by the next best substitute, in this case, ground-vehicle application. The following is a brief outline of the information included in this section:

- descriptive statistics of the Ag-Air industry;
- benefits and problems associated with aerial application;
- estimation of GA costs of aerial application;
- estimation of ground-vehicle application costs;
- estimation of Ag-Air direct benefits; and
- concluding remarks.

Description of the Ag-Air Industry

As Exhibit 3-12 indicates, about 8,500 aircraft accumulated almost 2.5 million flight hours in the Ag-Air industry in 1977. About 91 percent of these hours were by fixed-wing aircraft. Approximately 250 million acres were treated although this figure includes multiple applications so some double counting is involved. Still, the industry was responsible for the application of about 15 percent of all agricultural chemicals in the U.S.[1] Exhibit 3-12

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[1] Agricultural Aviation Study and Program Plan, NASA, Office of Aeronautics and Space Technology, June 1976, Vol. II, p. 8.

Exhibit 3-12

PROFILE OF AG-AIR INDUSTRY

Number of Aircraft	8,495
Annual Flight Hours	2.447 million
Acres Treated (Multiple Applications)	250 million
Number of Pilots*	6,500
Number of Operators*	4,000

*1974.

Sources: Number of aircraft, annual flight hours, acres treated, The Benefits of Improved Technologies in Agricultural Aviation, by Econ Incorporated, prepared for NASA, Office of Aeronautics and Space Technology, July, 1977, p. 5. Number of pilots, number of operators, Agricultural Aviation Study and Program Plan, NASA, Office of Aeronautics and Space Technology, June 1976, Vol. II, p. 8.

also suggests that most Ag-Air operators are quite small. Since about 4,000 Ag-Air bases operated only 8,500 aircraft, the typical operation employs only two or three aircraft.

Exhibits 3-13 and 3-14 provide characteristics of the Ag-Air fleet. The Piper Pawnee D, the Cessna Ag-wagon, the Stearman, and the Gruman Ag-cat are the four most prominent models. The typical fixed-wing craft weighs 3,431 pounds and has a cruise speed of about 94 miles per hour. Rotary wing aircraft, which comprise about 9 percent of the fleet, are dominanted by Bell models. The typical agricultural rotary wing aircraft weighs 2,638 and has a cruising speed of 87 miles per hour.[2]

Six crops--cotton, rice, wheat, corn, soybeans, and sorghum--dominate aerial treatment (see Exhibit 3-15). Cotton, rice and wheat account for about 50 percent of hours flown. About 90 percent of the total U.S. rice crop is seeded by air.

Benefits and Problems: Aerial Application

The following is a partial list of benefits accruing to aerial as opposed to ground applications of chemicals.[3]

- o Rapid application of pesticides when epidemics strike important crops.
- o Insects and weeds tend to thrive in wet weather when ground application is sometimes impossible.

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[2]The Benefits of Improved Technologies, pp. 8-10.

[3]Agricultural Aviation Study, pp. 28-29.

Exhibit 3-13

FIXED WING FLEET CHARACTERISTICS

Number in Fleet	Manufacturer Name and Model Number	Gross Weight (lbs.)	Cruise Speed (mph.)
2,720	Piper (Pawnee, Cub)		
1,259	PA-25-235	2,900	93
358	PA-18(A)-150	1,625	97
207	PA-36-285	3,800	-
201	PA-25-260	2,900	93
193	J3C-65	1,220	67
182	PA-25	3,300	81
129	PA-18(A)	1,500	97
70	PA-11	1,220	67
53	PA-18(A)-135	1,500	97
22	PA-18-125	1,500	97
46	Others	-	-
1,478	Cessna (Ag-Truck, Wagon)	3,300	108
1,138	(A)188B	3,300	108
298	(A)188(A)	3,300	96
42	Others	-	-
1,377	Boeing (Stearman)	2,717	93
1,134	Grumman (Ag-Cat)		
602	G-164(A) (B)	6,075	81
532	G-164(A)	3,725	98
737	Rockwell (Thrush)		
271	Aero-Commander	6,000	119
250	S-2R	7,000	82
133	Aero-Commander	3,000	82
60	Callair	2,350	93
23	Callair	2,150	93
309	Others		
115	N3N-3 (Naval)	3,200	94
49	S2C (Snow)	4,800	112
43	7AC (Aeronca)	1,220	90
34	201B (Weatherly)	3,500	96
29	AT301 (Air Tractor)	1,500	71
39	Others	-	-
7,755	Total Aircraft		

Source: The Benefits of Improved Technologies in Agricultural Aviation, p. 9.

Exhibit 3-14

ROTARY WING FLEET CHARACTERISTICS

Number in Fleet	Manufacturer Name and Model Number	Gross Weight (lbs.)	Cruise Speed (mph.)
460	Bell 47G, 47D	2,200-2,950	78
124	Hughes 269	1,575-1,670	64-65
112	Hiller UH-12	2,400-3,100	63-80
17	Continental Copters CH-13H Tom Cat	-	51
27	Others	1,600-7,200	71-90
740	Total Aircraft		

Source: The Benefits of Improved Technologies in Agricultural Aviation, p. 11.

Exhibit 3-15

MAJOR AG-AIR CROPS

Crop	Hours Flown	% U.S.	Area Harvested (1,000 Acres)	% U.S.
Cotton	564,600	23.1	10,899	3.3
Rice	410,200	16.8	2,501	0.7
Wheat	266,000	10.9	70,824	21.2
Corn	167,900	6.9	83,185	24.9
Soybeans	164,000	6.7	49,443	14.8
Sorghum	105,600	4.3	17,578	5.3

Source: The Benefits of Improved Technologies in Agricultural Aviation, p. 105.

- Ground vehicles sometimes spread infestations.
- Some crops have fixed planting schedules and optimum spraying times for chemicals. Poor ground conditions sometimes prohibit ground vehicles from making applications on schedule.
- The weight of ground vehicles causes soil compaction.
- Some land is inaccessible to ground vehicles.
- Ground vehicles cause crop damage.

However, there are some disadvantages to aerial application, most of which relate to weather and climate:[4]

- Wind velocity and direction affect both the space and density of the dosage.
- The vertical temperature gradient (inversions) affects the productivity of aerial application.
- Relative humidity affects evaporation rates of aerosol droplets.
- Weather conditions sometimes make aerial flights impossible.
- Aerial application is difficult over some terrains.

GA Costs of Aerial Application

The most current estimates of the costs of operating Ag-aircraft are offered by Gobetz and Assarabowski.[5] They apply the Akesson-

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[4]Akesson and Yates, The Use of Aircraft in Agriculture, Food and Agriculture Organization of the U.N., Rome 1974, pp. 105-112.

[5]F. W. Gobetz and R. J. Assarabowski, "Study of Future World Markets for Agricultural Aircraft," Contract NAS1-14795, NASA, April 1979, pp. 32-37.

Yates methodology to various representative aircraft in an attempt to estimate both fixed and variable costs of operation.[6]

The Akesson and Yates methodology involves the specification of a production function for Ag-aircraft. Model parameters are then substituted into the production function to determine productivity per acre per hour.[7] Operating costs for various aircraft cost classes are then combined with the production function to estimate either cost per acre or cost per hour of operation. This provides estimates of variable costs.

Specifically, the following three aircraft are included in their analysis:

- o Piper Pawnee (Cost Class C),
- o Cessna Ag Wagon (Cost Class B),
- o Ayres Turbo Thrush (Cost Class A).

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[6]The Use of Aircraft in Agriculture, pp. 121-135.

[7]Specifically, the following production function was specified:

$$A/T = Q_L / \left[(T_R/60) + (D_F/V_F) + (KQ_L/Q_A S_W) \cdot (1/V_S + T_T/60D) \right]$$

where,

A/T = Productivity in acre/hours;
Q_L = Aircraft load in pounds;
Q_A = Application rate in pounds/acre;
T_R = Loading time (minutes);
T_T = Turning (end of swath) time (minutes);
D_F = Ferry distance in miles;
D = Field or run length in miles;
S_W = Swath width in feet;
V_F = Ferry speed in miles/hour;
V_S = Field speed in miles/hour;
K = Constant = 8.25

This function, of course, defines productivity per hour.

These aircraft were selected as being representative of the three Akesson-Yates cost classes.

A breakdown of the composition of the fixed-wing fleet is also provided:[8]

Class C - 58%

Class B - 19%

Class A - 23%

This information, together with data on hours flown and number of aircraft, is sufficient to obtain an estimate of the total cost of GA aerial application in agriculture.

Columns (1) and (2) of Exhibit 3-16 display the Gobetz and Assarabowski estimates of fixed and variable costs of the three aircraft sizes. Pilot allowances are included in variable costs. Rotary wing costs are estimated as the average of Class A and B aircraft type costs.[9] The number of aircraft in each cost class was obtained by weighting total fixed wing fleet by the percentages provided in the preceding paragraph. No data on the breakdown of hours flown by cost class is available. Therefore, it was assumed that hours flown were directly proportional to the fleet composition. Total costs of Ag-Air application are provided in column (5). These figures were computed as:

Total Cost (GA) = (Fixed Cost/Yr.) x (Number of Aircraft) + (Variable Cost/Hr.) x (Hours Flown)

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[8]"Future World Markets," p. 64.

[9]The U.S. Ag-Air helicopter fleet is split between cost Class A and B. See Akesson and Yates, pp. 182-183.

Exhibit 3-16

COSTS OF AERIAL APPLICATION

Aircraft (Cost Class)	(1) Fixed Cost/Year	(2) Variable Cost/Hour	(3) Number of Aircraft	(4) Hours Flown (000)	(5) Total Cost GA ($ Millions)
Pawnee (C)	$10,722	$40	4,512	1,292	$100.1
Improved AG Wagon (B)	13,546	53	1,519	423	43.0
Turbo-Thrush (A)	44,824	68	1,807	512	115.8
Rotary Wing (A-B)	28,732	57	740	220	33.8
Total					292.7

Summing across aircraft types provides an estimate of $292.7 million as the total cost of aerial application in 1977.

This figure was checked against a second cost estimate obtained from data available in FAA: Selected Statistics United States General Aviation 1959-1976. Briefly, annual flight hours and fleet size were obtained from the aerial application use category. These data were matched to fixed and variable cost data by aircraft type (also from Selected Statistics). Pilot allowances were added. After adjusting for growth of the Ag-Air fleet and inflating to 1977 dollars, we obtained an estimate of about $280 million.

Although this estimate is reasonably close to our first estimate using the Gobetz and Assarabowski methodology, the FAA cost estimates are by general aircraft type and are, therefore, not specific to Ag-aircraft. Hence, we adopt the higher figure of $292.7 million as a more accurate estimate of GA aerial application. Still, the FAA estimate serves as a verification of the Gobetz-Assarabowski estimate.

It must be stressed here that these cost estimates are for typical operations. Variable costs fluctuate depending upon weather, application rates, and especially field size which affects ferrying distance.[10]

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[10] See "Future World Markets," pp. 85-98, for sensitivity of costs to field size and application rates.

Estimation of Ground Vehicle Costs

Identifying an appropriate substitute for Ag-Air poses some special problems:

- o Under some conditions (weather, terrain, etc.) ground application may be virtually impossible.
- o A wide range of ground vehicle substitutes exist ranging from specialized spraying tractors to portable spraying equipment mounted on pick-up trucks.
- o Each of the various ground vehicle substitutes has widely varying operating and fixed costs.

Gobetz and Assarabowski also offer cost comparison estimates with a specific ground vehicle. They selected the John Deere 6000 Hi-Cycle Sprayer for the following reasons:[11]

- o The high clearance of the vehicle permits spraying of tall plants in later stages of maturity.
- o The high clearance causes minimal crop damage.
- o Although designed for low-volume insecticide work, costs of other applications does not vary widely.

Both fixed and variable costs were estimated from engineering data. Specifically, regression analysis provided estimates of both costs as a function of initial purchase price.[12] They estimate application costs per acre to be $2.31.[13] This estimate was apparently confirmed in correspondence with John Deere.

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[11] "Future World Markets," p. 99.

[12] See Agricultural Machinery Management, Agricultural Engineers Yearbook-1978, ASAE Engineering Practice, ASAE EP391, 1978 and ASAE Data, ASAE D2330.3, 1978.

[13] Discounted to 1977 dollars by 8 percent.

Given that some 250 million acres were treated by Ag-Air in 1977, the total cost of the substitute (TC_S) is:

TC_S = 250 million x \$2.31 = \$577.5 million

It should be noted that the John Deere 6000 Hi-Cycle sprayer is one of the more expensive ground vehicles to operate; hence, this cost estimate may be high. Nonetheless, the Hi-Cycle sprayer is a likely substitute because of its ability to perform tasks similar to Ag-aircraft. Clearly, it would be inappropriate to substitute a lower cost ground vehicle incapable of similar performance.

Benefits of GA Ag-Air

The direct benefits (B_{GA}) of Ag-Air attributable to cost savings is given the difference of the substitute and GA costs. Specifically:

$B_{GA} = TC_S - TC_{GA}$ = \$577.5 - 292.7 = \$284.8 million

Some observers of the Ag-Air industry claim that additional benefits accrue to the industry because of higher agricultural productivity; i.e., aerial application causes less crop damage than ground vehicles and permits more timely application of chemicals. Productivity increases as high as 10 percent have been claimed.[14]

Exhibit 3-17 provides estimates of the value of the six major Ag-Air crops. The sum totals to about \$33.9 billion. If just

[14] World of Agricultural Aviation, National Agricultural Aviation Association (NAAA), April 1975.

Exhibit 3-17

AG-AIR PRODUCTION - MAJOR CROPS

Crop	Production (1,000 Units)	Price (Per Unit)	Value of Crop ($ Thousands)
Cotton	10,557 bl	$239.52	$ 2,528,613
Rice	117,019 cwt	7.93	927,961
Wheat	2,147,408 bu	3.52	7,558,876
Corn	6,216,032 bu	2.46	15,291,438
Soybeans	1,264,890 bu	4.60	5,818,494
Sorghum	723,679 bu	2.36	1,706,145
Total			$33,885,527

Source: The Benefits of Improved Technologies in Agricultural Aviation, p. 105.

10 percent of this production is directly attributable to Ag-Air, then the industry provides additional benefits of $339 million. However, we hesitate to adopt this as a hard figure because of the difficulty of estimating productivity attributable to Ag-Air as an input. If, however, this estimate is accurate total direct benefits attributable to the Ag-Air industry, including cost savings and productivity increases, totals $623.8 million, a substantial figure for a relatively small industry.

Concluding Remarks

The above estimates of the direct benefits of agricultural aviation must be accepted in view of the following qualifications (other than those previously acknowledged):

- The benefits estimated accrue to typical operations. Ag-Air benefits may be most significant in atypical operations.
- As a GA use category, aerial application includes such activities as fire-fighting, locust and termite control, etc. We have not included estimates of these benefits which may be substantial.
- Although our estimates of direct benefits are substantial and, in some cases, no substitutes may be available, the Ag-Air industry is not indispensible, given that only about 15 percent of all chemical applications are by aviation.

AN EXAMPLE OF INDUSTRIAL AND SPECIAL USE OF GA AIRCRAFT: THE CASE OF THE GULF COAST HELICOPTER INDUSTRY

General aviation aircraft have a broad range of special and industrial applications. Some of the more common uses of general aviation aircraft in special and industrial settings are:

- Bank paper transportation;
- Ambulance service;
- Coastline surveillance to protect fishing rights, monitor smuggling and oil slicks;
- Law enforcement;
- Airborne television camera platform and transmission station;
- Rescue service for mountaineers, flood and fire victims, etc.[1]

Unfortunately, it is precisely this diversity of applications that makes the special and industrial uses of general aviation aircraft difficult to evaluate. Few of the uses are extensive enough to have had well documented data recorded concerning them. Also, there have been no attempts to compile aggregate data on this portion of general aviation.

In order to examine some of the possible benefits of general aviation in special and industrial uses one major application of helicopters--the employment of helicopters in the offshore

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[1]From pamphlet printed by Helicopter Association of America.

oil industry in the Gulf of Mexico. Helicopters are rapidly replacing boats in the transportation of personnel to and from offshore oil rigs and platforms. In 1977, nearly 400 helicopters flew 257 million passenger miles in 396,000 hours in the Gulf.[2]

The major advantages of helicopter transportation over boat transportation are speed and comfort. Helicopters travel at speeds ranging from 85 to 175 mph, while crew boats average a speed of about 25 mph. Not only is the boat ride a longer one, but since the boat travels on the water's surface, boat trips often produce motion-sickness which is typically absent in helicopter trips. As a consequence, helicopters are used almost exclusively in transporting personnel to rigs more than a few miles away from shore, while boats have been relegated to carrying non-critical supplies. (By 1979, 1.5 percent of the offshore oil industries dollar outlays were allocated to helicopter expenditures.[3])

Despite the fact that there are relatively few operators in the Gulf, it has not been feasible to collect data which adequately represents the several facets of helicopter transportation in the offshore oil industry--e.g., flights between shore and rigs, flights between rigs, flights carrying full-time vs. part-time personnel, flights carrying executive personnel staying aboard a rig for a brief period. The irregularity of trips between rigs

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[2] William Thora of Aerospatiale Helicopter Corp.

[3] In "The Business Helicopter," Airport Services Management, January 1979.

and of trips involving part-time personnel or occasional visitors to offshore rigs makes the measurement of economic activity difficult.[4] This study will therefore focus on the transportation of full-time personnel to and from offshore oil rigs and in particular will compare helicopter transportation of such workers to boat transportation in terms of benefits and costs.

A "snapshot" of the Gulf of Mexico as it looked in September of 1977 was taken by plotting on a map the location of all oil rigs and platforms located in the Louisiana and Texas waters in September of 1977.[5] Their distances from shore were measured and summed by rig type. Exhibit 3-18 lists the six different types of rigs and platforms, the complement of full-time manpower stationed on each structure at any given time, and their cumulative distances from the nearest helicopter base. Multiplying the manpower complement by the cumulative distance gives the total number of passenger miles travelled when these workers are brought out to the rigs. The typical shift for offshore oil workers in the Gulf of Mexico is seven days on, followed by seven days off.[6]

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[4]"Industry Cracks Down on Manpower Pressure," Offshore Magazine, January 1979. Figures listed in Offshore are total complement--the number of people working at any time is one-half of that (since there are two shifts). Also, figure of 34 for drillships and barges was arrived by weighted the Offshore figures in a 2:1 ratio[6] (which represents their existence in the Gulf) and then dividing by two.

[5]Information on rig locations was obtained from "Offshore Rig Newsletter" of Offshore Rig Data Service (Houston, Texas).

[6]Loron Sheffer of Offshore Data Service.

Exhibit 3-18

DERIVATION OF PASSENGER MILES PER TRIP

RIG TYPE / DESCRIPTION	MANPOWER COMPLEMENT*	CUMULATIVE DISTANCE FROM NEAREST BASE** (Miles)	PASSENGER MILES
1) Mobil Rig: Submersible	30	488.85	14,666
2) Mobil Rig: Semi-Submersible	40	1,747.29	69,892
3) Mobil Rig: Dullships & Barges	34	412.42	14,022
4) Mobil Rig: Jackups	28	2,814.49	78,806
5) Platform Rig: Self Contained,	23	7,747.13	178,184
6) Platform Rig:	23	890.92	20,491

TOTAL PASSENGER MILES TRAVELED IN A SINGLE TRIP = 376,061 miles

TOTAL PASSENGER MILES TRAVELED BY FULLTIME WORKERS ON HELICOPTERS IN 1977:

376,061 passenger miles x 52 weeks/year x 2 crews/change = 39,110,344

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*See footnote 4 on previous page.

**See footnote 5 on previous page.

Each week a complement of workers is brought out to a rig while another complement is brought in from the same rig. Thus, summing the passenger miles and multiplying by the number of crew changes, yields total passenger miles travelled by full-time offshore workers in 1977.

Of the different helicopters servicing the Gulf in 1977, only four models were used for regular crew changes because of their larger passenger capacities (see Exhibit 3-19). The Bell 212, which constituted 73.5 percent of all such large helicopters available,[7] is used as the "typical" helicopter employed in crew changes. It's operating characteristics are given in Exhibit 3-20. Dividing the total passenger miles by the speed of the Bell 212 yields total passenger flight hours in crew changing (Exhibit 3-21).

An important element in calculating the benefit of helicopter over boat transportation is the value of the offshore workers' time spent in transport. Exhibit 3-22 lists the composition of a 24-man complement, along with their estimated 1977 hourly wages.[6] The weighted average salary is $6.76 per hour. Assuming this to be the average salary for any offshore worker, the value of the workers' time spent during helicopter transport can be determined by multiplying this figure by the total passenger flight hours (Exhibit 3-22A).

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[7] From 1977 Directory of Helicopter Operators in the United States, Canada, and Puerto Rico of the Aerospace Industries Association of America, Inc. (AIA).

Exhibit 3-19

HELICOPTERS USED FOR REGULAR CREW CHANGE*

NAME	NUMBER OF PASSENGERS	NUMBER USED	PERCENT OF TOTAL
Bell 204/205	8-10/14	12	17.6
Bell 212	14	50	73.5
Aerospatiale Dauphin	13	2	2.9
Aerospatiale Puma	18	4	5.9
		TOTAL	100.0

*See footnote 7 on previous page.

Exhibit 3-20

OPERATING CHARACTERISTICS OF BELL 212*

Number of passengers (other than pilot)	14
Direct operating cost/hour**	$ 108.06
Indirect operating cost/hour**	124.28
Total operating cost/hour	$ 232.34
Crusing speed (mph)	115

Exhibit 3-21

TOTAL 1977 PASSENGER MILES:

39,110,344 passenger miles ÷ 115 mph = 340,090 passenger hours

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*From specification sheets provided by Bell Helicopter-Textron.

**Assumes 1200 hours use per year.

Exhibit 3-22

SALARY DATA*, **

# ON BOARD	POSITION	1977 ADJUSTED WAGE/HOUR
1	Toolpusher/Supervisor	$ 11.81
1	Driller	10.31
2	Derrickman	7.98
6	Rotary Helpers	7.15
1	Maintenance Foreman	7.22
4	Maintenance Helpers	5.27
1	Welder	7.08
2	Powerplant Foreman	7.77
2	Powerplant Helpers	5.27
1	First Cook	5.55
2	Utility Cooks	4.93
1	Quartermaster	4.51
24		

WEIGHTED AVERAGE ADJUSTED SALARY = $6.76/Hour

Exhibit 3-22A

1977 VALUE OF WORKERS' TIME SPENT ON HELICOPTER:

340,090 passenger hours x $6.76/hour = $2,299,008

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*Loron Sheffer of Offshore Data Service.

**Using October 1976 data (based on 12 hour day, 7 day shift) for all but toolpusher/supervisor; toolpusher/supervisor figure based on 1979 figure of $2600/month. Salaries are estimated to change 10 percent per year.

Workers are paid 40 hours at regular wage, 44 hours at time and a half $\Rightarrow$1.2619 times normal wage for 84 hours - adjusted wage.

To account for the value of the pilots' time, note that the helicopter only holds 14 passengers, while each rig has a manpower complement larger than this. Thus, the pilot must make multiple trips in order to transport an entire complement of workers to or from a rig. Exhibit 3-23 computes the number of hours of pilots' time required in changing crews in 1977. Assuming an average pilot's salary of $20,000 per year in 1977 or $9.62 per hour[8] (based on 40 hours per week, 52 weeks per year), the value of the pilots' time in transporting personnel may then be calculated (Exhibit 3-23A).

The total operating cost for the helicopters used in 1977 may be calculated using the pilots' flight hours for the helicopter flight time (Exhibit 3-24A). The total cost of the helicopter's use is then its operating costs plus the value of the pilots' time (Exhibit 3-24B).

The determination of miles travelled in the case of crew change by boat requires a somewhat different approach. The typical crew boat used in 1977 was a 100-foot boat, with estimated passenger capacity ranging from 40 to 100 passengers (characteristics of a typical 100-foot boat are given in Exhibit 3-25).[9, 10] Assume

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[8]From "The Offshore Transportation Industry," Business and Commercial Aviation, January 1979.

[9]From Paul Haynes of Comar, Inc. (Boat Operator in New Orleans).

[10]David André of Offshore Logistics, Inc. (Lafayette, Louisiana).

Exhibit 3-23

DERIVATION OF PILOT FLIGHT TIME AND PILOT EXPENSES

(A) PILOT'S FLYING TIME:

A RIG TYPE	B MANPOWER COMPLEMENT	C CUMULATIVE MILES	D # OF TRIPS REQUIRE	E C x D
1	30	488.85	3	1,466.55
2	40	1747.29	3	5,241.87
3	34	412.42	3	1,237.26
4	28	2814.49	2	5,028.98
5	23	7747.13	2	15,494.26
6	23	890.92	2	1,781.84
		MILES TRAVELED BY PILOTS		= 30,850.76 miles

HOURS TRAVELED BY PILOTS:

30,850.76 miles ÷ 115 mph = 268.27 hours

Exhibit 3-23A

1977 VALUE OF PILOT'S TIME SPENT ON HELICOPTER:

268.27 x $9.62/hour x 52 weeks/year x 2 crews/change = $268,396

Exhibit 3-24

HELICOPTER OPERATING AND PILOT COSTS

(Exhibit 3-24 A) Total of Operating Cost for Helicopter:

268.37 hours x $232.34/hour x 52 weeks/year x 2 crews/change = $6,482,305

(Exhibit 3-24 B) Total 1977 Cost of Helicopter Use:

$6,482,305 + 268,399 = $6,750,704

Exhibit 3-25

OPERATING CHARACTERISTICS OF 100 FOOT CREW BOAT *

Cost per hour:	
Fuel: 100 gallon/hour @ .40/gallon	$40.00
Maintenance and Supplies	15.00
Crew: $210/day ÷ 12 hours/day	17.50
Total Variable Cost Per Hour	$72.50

Depreciation = $50,000/year**

Speed: 23 knots = 26.5 mph

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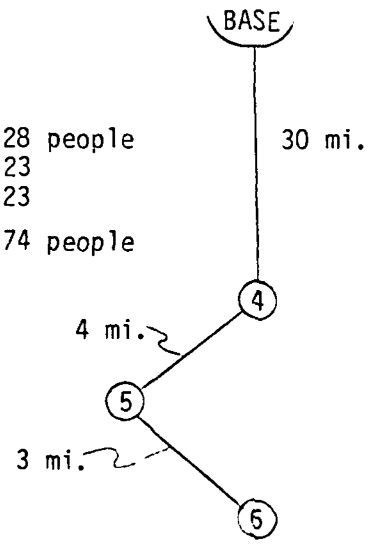
*From Paul Haynes of Comar, Inc. (Boat Operator in New Orleans).

**Based on $600,000/1977 cost depreciated over 12 years.

that the boat carries 60 passengers on average, but never more than 75 (its practical maximum capacity). Thus, a boat can accomplish crew changes for two or three platforms on each trip. The accompanying diagram show how a crew boat might effect a crew change for three rigs during the course of a single trip:

Rig Type (4) → 28 people
(5) → 23
(6) → 23
Total → 74 people



In this case, the arriving crew of rig type (4) has travelled 30 miles, the crew of rig type (5), 34 miles, and rig type (6), 37 miles. The boat has travelled 37 miles from shore. Its return voyage is shorter unless the rigs are aligned perfectly relative to the base.

Using the "snapshot" of the rigs, groupings were made in which no rig was greater than 15 miles from any other rig in the group and the total number of workers required on those rigs did not exceed 75. Calculations of passenger miles and boat miles are given in Exhibit 3-26. Using the operating characteristics

Exhibit 3-26

CREW BOAT PASSENGER MILES

RIG TYPE	CUMULATIVE DISTANCE FROM BASES	MANPOWER COMPLEMENT	PASSENGER MILES
1	523.77	30	15,713
2	1748.02	40	69,921
3	412.33	34	14,019
4	2891.07	28	80,950
5	7929.75	23	182,384
6	893.11	23	20,542
		Total Passenger Miles =	383,529

of the 100-foot crew boat (Exhibit 3-25), we can determine the value of the worker's time spent on the boat and the cost of the boats using the data in Exhibits 3-25 and 3-27.

Finally, we can find the net benefits and net costs of helicopter transportation versus boat transportation (see Exhibit 3-28).

Interpreting Results

Based on the above analysis, the economic benefit of utilizing helicopters in lieu of boats in the transportation of full-time oil rig workers in the (U.S.) Gulf of Mexico is approximately \$3.6 million. If the benefits are evenly distributed among the 68 helicopters used in these operations, the average return per helicopter is on the order of \$53,000. Such a benefit represents a return of approximately eight percent on the retail value of a new Bell 205 helicopter. Recall that this return is only for the transportation of full-time crew members.

The economic benefit discussed above is equivalent to 9.2¢ per passenger mile. Full-time rig employees account for less than 20 percent of the passenger miles in the Gulf oil service industry. Consequently, the actual benefits are at least on the order of \$23.7 million for all passenger operations based on 257 million passenger miles. This estimate assumes all passengers transported have the same average wage as rig workers. Obviously this is not the case, but in all likelihood the oil rig worker's wage underestimates the average compensation of all passengers

Exhibit 3-27

CREW BOAT COSTS AND VALUE OF PASSENGER TIME

TOTAL BOAT MILES = Distance of all platforms from base which were the only stops on the trip, plus the distance travelled by boat to the final platform when there were multiple loads

= 8647.7 miles

HOURS OF BOAT TRAVEL: IN 1977

8647.7 miles ÷ 26.5 mph x 52 weeks/year x 2 crews/change

= 33,938 hours

TOTAL 1977 VARIABLE COST:

33,938 hours x \$72.50/hour = \$2,460,515

TOTAL 1977 COST OF BOAT USE:

\$2,460,515 + \$50,000 = \$2,510,515

VALUE OF WORKERS' TIME SPENT ON BOAT:

383,529 passenger miles ÷ 26.5 = 14,472.79 passenger hours

14,472.79 passenger hours x \$6.76/hour x 52 weeks/year x 2 crews/change = \$10,174,952

Exhibit 3-28

DERIVATION OF HELICOPTER NET BENEFITS

BENEFITS IF HELICOPTER TRANSPORTATION OVER BOAT:

= Workers' Time Value on Boat - Workers' Time Value on Helicopter

= $10,174,952 - 2,299,008

= $7,875,944

COST ADVANTAGE OF BOAT TRANSPORTATION OVER HELICOPTER:

= Total Cost of Helicopter Use - Total Cost of Boat Use

= $6,750,704 - 2,510,515

= $4,240,189

NET BENEFIT OF HELICOPTER TRANSPORTATION OF FULLTIME OFFSHORE PERSONNEL OVER BOAT TRANSPORTATION FOR 1977:

= Benefits of Helicopter Transportation - Cost Advantage of Boat Transportation

= $7,875,944 - 4,240,189

= $3,635,755

which include managers, geologists and other professional or supervisory personnel.

Other reasons to suspect that the $23.7 million economic benefit estimate is conservative are as follows. First, helicopters not only increase transit productivity but also production productivity by allowing companies to schedule and maintain optimal crewing complements. Estimating these productivity effects was beyond the scope of this project, however.

Second, the method employed also ignores the nonpecuniary benefits of helicopter transportation versus boat transportation. Greater comfort, less susceptibility to motion sickness and less time spent in transit are very real benefits enjoyed by helicopter passengers when compared to their counterparts transported in boats. Some or all of these benefits may contribute to higher productivity by increasing worker satisfaction.

There are at least two offsetting tendencies in the analysis which may contribute to overestimation of benefits. First, neither helicopters nor boats are used exclusively to transport full-time work crews. The actual, realized benefits of helicopter transportation may therefore be overstated. A second reason for suspecting overestimation is that return legs of boat trips are less circuitous than outgoing (from shore) voyages. Thus, round-trip boat transit times may be slightly overstated.

However, given the probable relative sizes of these errors in estimation, it can be said that the stated benefits are probably too low.

DIRECT BENEFITS: PERSONAL USE

The methodology described below attempts to measure the direct benefits attributable to the General Aviation Personal Use Category. Direct benefits are defined as the loss in consumer surplus that would have occurred if GA/Personal Use had not been available to the 1977 economy and the next best substitutes were used.

Relative to other use categories, Personal Use presents unique difficulties in measuring direct benefits because it may be characterized as both an intermediate and a final good. That is,

- o Transportation may be considered an an input to some final good or activity; to the extent that the personal aircraft provides transportation, it may be considered an intermediate good or input to some other recreational activity.
- o Personal users receive satisfaction--i.e., recreational utility--from owning and operating their aircraft; as such, personal flying can be considered a final good.

In view of the final good characteristic, any attempt to measure direct benefits by considering only the transportation characteristic is likely to seriously underestimate the actual benefits accruing to this use category. Indeed, the income (or value of time) of many personal flyers is insufficient to justify the use of aircraft as an intermediate good alone. Accordingly, the methods employed for other use categories are inappropriate here.

Consumer Surplus

As an alternative, we have attempted to use consumer surplus as a measure of direct benefits.[1] The idea is to measure the value of the benefits received by personal flying in excess of the cost of aircraft operating costs. Of course, if the demand curve for personal flying is identified, at least crude measures of surplus are possible. Suppose, by way of illustration, that the demand for personal flying can be represented by demand curve D in Exhibit 3-29. Consumer surplus can be measured by the area of the shaded triangle if P_1 and Q_1 are the existing equilibrium price and quantity respectively. Algebraically, this area can be expressed as:

$$\text{Consumer Surplus} = 1/2 \left[(P_0 - P_1)Q_1\right]$$

We argue that this area is an appropriate measure of direct social benefits because it represents an amount the personal flyers would be willing and able to spend--i.e, the value of resources--on substitute transportation/recreational goods and services if GA were not available; that is, in a full employment economy, national output would decline by this amount because additional resources would be required to produce the substitute goods and services.

Of course, two additional conditions must exist to insure the validity of this measure:

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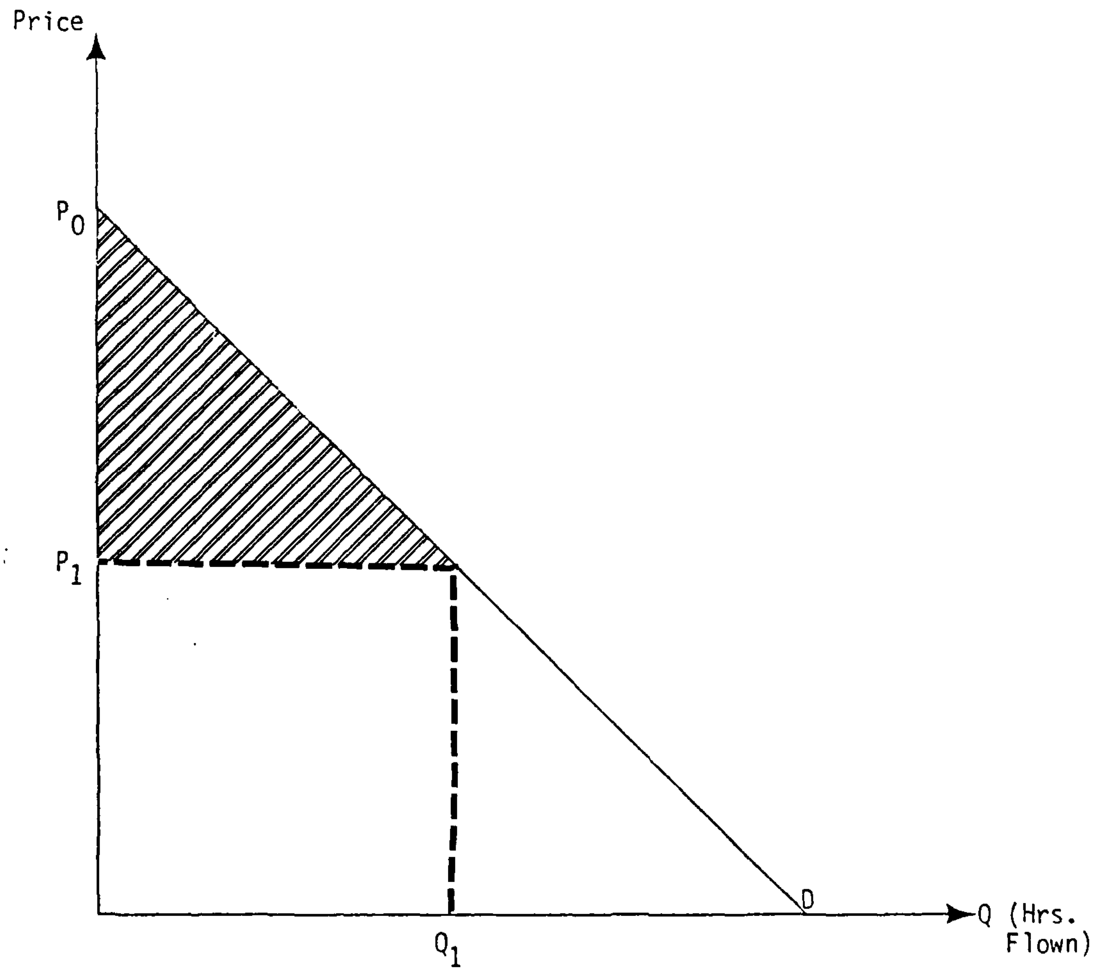
[1]Both the conceptual and practical difficulties of using and measuring consumer surplus are discussed later.

Exhibit 3-29

CONSUMER SURPLUS



- Perfect competition in the personal flying market; that is, the initial P_1 and Q_1 must be optimal.
- Resource prices must accurately reflect their true opportunity costs after displacement.

It is often argued that consumer surplus is a valid measure only if income-compensated demand curves are considered; however, in this case:

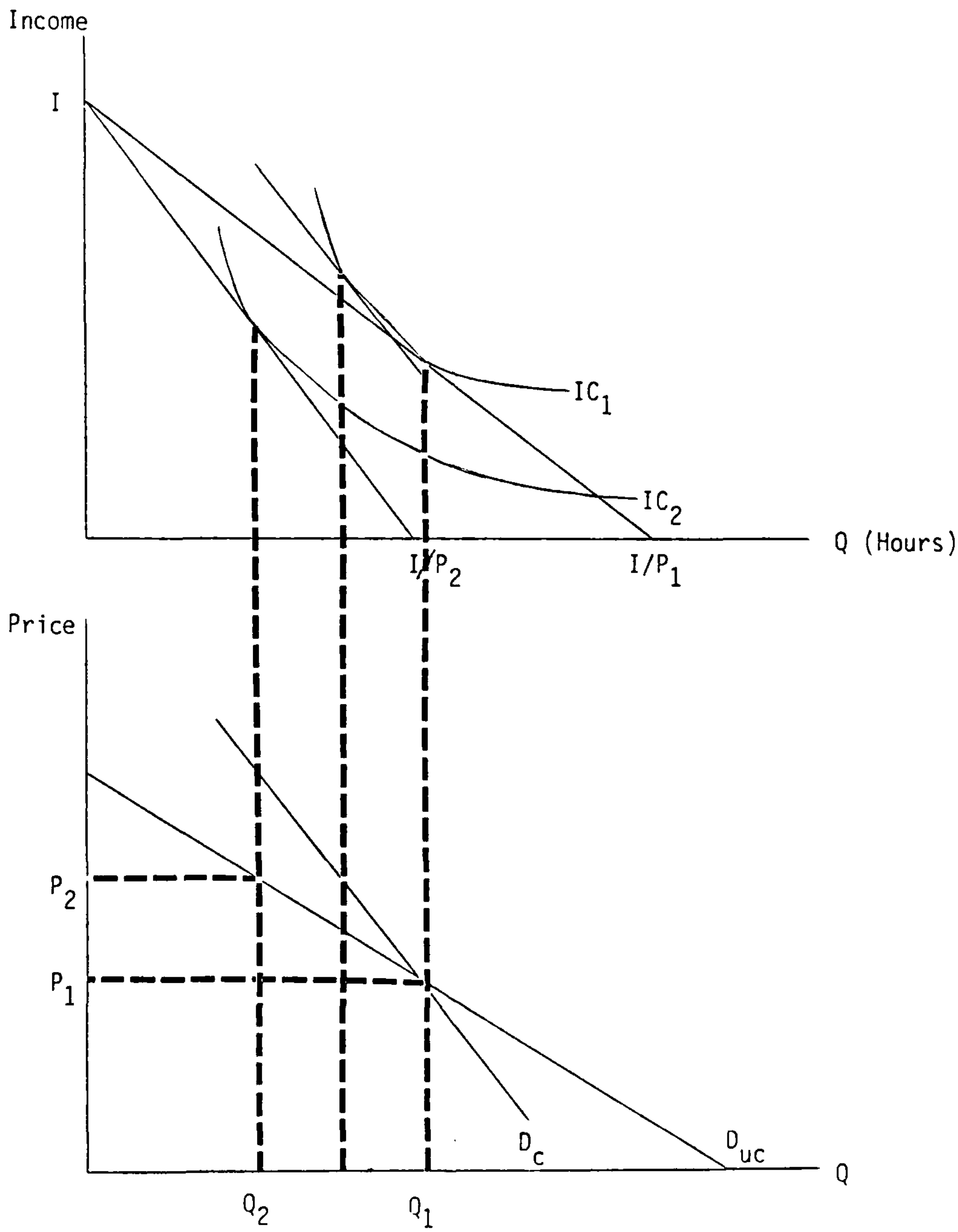
- The identification of income-compensated demand curves poses intractable estimation problems.
- Within the context of this task, the uncompensated demand curve is appropriate.

The second point deserves further explanation. The problem is illustrated in Exhibit 3-30. IC_1 represents the personal flyers initial indifference curve between income and flying. The initial price line is given by the segment $I - I/P_1$, were P_1 is the initial cost of flying. Q_1 represents the consumer's optimal flying given P_1. As the cost of flying increases, the price line rotates to the left to say, $I - I/P_2$ with optimal flying at Q_2. The shift from IC_1 to IC_2 includes both income and substitution effects; thus, the demand curve traced by this movement, D_{uc}, is not income compensated.

The compensated demand curve, D_c, is traced by a parallel shift of the second price line to a point of tangency to IC_1, the initial indifference curve. Note that D_c is inelastic relative to D_{uc}; hence, D_{uc} will underestimate consumer surplus relative to D_c.

Exhibit 3-30

COMPENSATED AND UNCOMPENSATED DEMAND CURVES



Since D_c is income-compensated, it will provide an accurate measure of consumer utility received from flying; however, it is not relevant for this task since points above (P_1, Q_1) are not attainable by the consumer. That is, the consumer can no longer afford to reach IC_1, if the price of flying increases to P_2.

In other words, the surplus under D_c will not represent the amount of extra resources that the consumer will spend on transportation/recreation in the absence of GA because the consumer, in reality, is constrained by his income. The actual adjustment of the consumer will be described by D_{uc}, the uncompensated demand curve, even though the consumer will be placed on a lower level of utility. Thus, we interpret "best" substitute as the alternative the consumer would actually select and not a "perfect" substitute that would leave the flyer at the same level of utility. Therefore, the resulting estimates are the net change (decline) in consumer benefits in the absence of GA.

Estimation of Demand

Demand for personal flying (hours of operation) was specified as a function of the cost of operation (average total cost per hour) and lagged disposable personal income. Average total cost (ATC) is included as a price variable while lagged disposable income (DPI_{t-1}) is primarily a cyclical variable included to account for the sensitivity of personal aircraft use to the business cycle. Specifically,

$$HRS_t = A_0 + A_1 HTC_t + A_2 DPI_{t-1} + e_t$$

Both hours of operation and ATC are annual data (1959-1976) obtained from FAA Selected Statistics United States General Aviation 1959-1976. All figures were expressed in terms of 1967 constant dollars. The expected signs of A_1 and A_2 are negative and positive respectively.

Using regression analysis, estimates of the demand equations were obtained for the following aircraft types:

- o Single-engine piston less than three seats (SPL3S),
- o Single-engine piston four seats and over (SPG3S),
- o Twin-engine piston less than 12,500 lbs. (TEP).

These aircraft account for the bulk of personal flying.

The results of the regression analysis are detailed in the Appendix B. Briefly, the signs of the coefficients are as expected and all are significant at 95 percent. Adjusted R^2's vary from .782 to .958. Cost elasticities (evaluated at the sample means) vary from -.834 (SPL3S) to -.595 (TEP 12,500 lbs.).

Estimates of consumer surplus are provided in Column (3) of Exhibit 3-31.[2] For example, total consumer surplus derived from SPL3S, personal use, is $118.38 million. To put this figure in perspective, the ratio of consumer surplus to the cost of operating the personal fleet (SPL3S) was calculated as .4159. This suggests that the average personal flyer of this aircraft type would be

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[2] See Appendix B for details.

Exhibit 3-31

ESTIMATES OF CONSUMER SURPLUS

(1) A/C Type	(2) Elasticity	(3) Consumer Surplus ($ Million)	(4) Average Income Required
SPL3S	-.834	$118.38 (.4159)[a]	$33,317 (1.192)[b]
SPG3S	-.717	487.70 (.7755)	46,360 (1.272)
TEP (<12,500 lbs.)	-.595	153.73 (.8958)	78,575 (1.589)

[a]Ratio of consumer surplus to actual cost of operating the fleet.

[b]Ratio of estimated required income to Vahovich Incomes.

willing to pay $1.42 for every $1 currently spent before flight hours would be reduced to zero. Ratios for the other aircraft types are .7755 (SPG3S) and .8958 (TEP).

These estimates of consumer surplus should be viewed as upward biased. The costs per hour required to drive flight hours to zero are far in excess of observed costs. In estimating consumer surplus, we have assumed that the upper half of the demand curve can be estimated from a linear interpolation of the observed portion of the curve. Most likely, the slope of the curve falls (becoming increasingly elastic) as costs move above observed prices.

Certainly, the demand curve is constrained by the incomes of personal flyers. Column (4) of Exhibit 3-31 provides estimates of the average income required to generate our estimates of surplus. These estimates were obtained as follows:

- Bureau of Labor estimates for minimum income required for a moderate standard of living ($17,106) were added to per capita surplus plus cost of operation for the single-engine pistons and $25,000 was added to the same figure for the twins. This assumes that personal flyers would be willing to spend all discretionary income on flying.
- An effective income tax rate of 25 percent on income greater than the BLS minimum was assumed (BLS figures include taxes).

These income estimates were then compared to income data from the Vahovich User Survey. For example, Vahovich estimates the average income of personal users (SPL3S) at $27,933 (1977 dollars). This implies a ratio of estimated income to income observed by Vahovich of 1.192. In general, our estimates are higher than Vahovich's actual estimates; however, Vahovich's highest income bracket is $100,000 (i.e., users with incomes over $100,000 are understated). In addition, some of the incomes listed in his survey are unrealistically low (perhaps due to shared ownership arrangements). In view of these considerations, the minimum estimates required to generate surpluses do not appear to be unreasonable.

Still, we view these estimates as upperbound for the following reasons:

- The assumption that flyers are willing to spend all discretionary income on flying undoubtedly overstates the personal flyers commitment to aviation.
- Families with incomes of $46,000 and $78,000 probably require budgets greater than $17,106 and $25,000 for "non-discretionary" expenses.

DIRECT BENEFITS: AIR TAXI AND AIRCRAFT RENTAL

The two remaining use categories that can be examined in order to determine resource benefits and consumer benefits are air taxi (excluding commuter air carriers) and aircraft rentals. Both of these services are generally sold by FBO's, although some operators specialize in one or the other activity exclusively.

The approach used to estimate direct benefits in these two categories is straightforward and is based on the analyses of executive/business, personal and aerial application use categories described immediately above. First, hours in each category are allocated to executive/business, personal or aerial application based on the incidence of these activities in the general aviation fleet (see Exhibit 3-32). Instructional use of rental aircraft has been excluded because it is an input into the production of current and future GA activity. The diversity of uses of industrial/special uses of rental aircraft precludes estimation of benefits. Therefore, in Exhibit 3-32, the allocation of hours among the three included categories does not sum to the total rental hours. Notice also that the number of rental hours in several use categories was negligible and was therefore ignored because any resulting estimates would be well within the margin of error of the analysis.

The second step in estimating the direct benefits of air taxi and rental operations was to derive the average per hour

Exhibit 3-32

USES OF AIR TAXI AND RENTAL HOURS BY AIRCRAFT TYPES

	Single-Engine Piston (1-3 Seats)	Single-Engine Piston (+3 Seats)	Twin Piston	Twin Turboprop	Twin Turbojet	Piston Rotary	Turbine Rotary
Total Air Taxi Hours	12,553	834,000	1,119,260	78,555	213,883	37,404	648,811
Personal Use Hours	6,025	400,320	537,245	-	-	-	-
Executive Use Hours	6,527	433,680	582,015	78,555	213,883	37,404	648,811
Total Rental Hours	503,180	1,913,162	160,186	77,975	-	-	-
Personal Use Hours	137,195	661,779	13,184	-	-	-	-
Business Use Hours	22,541	559,943	52,473	-	-	-	-
Executive Use Hours	-	42,794	46,907	59,522	-	-	-
Aerial Application Hours	90,294	-	-	-	-	-	-

Sources: Total Hours: FBO chapter, Analysis of GNI and GNP Contributions of Air Taxi, Flight Instruction and Aircraft Rental.
Segregation of air taxi hours based on ATA survey of users of scheduled air carriers.
Segregation of rental hours based on use of aircraft as found in: FAA, "Selected Statistics United States General Aviation 1959-1976," DOT-FA77WA-4041 (1978).
A "-" indicates that the use category is probably negligible for that aircraft type.

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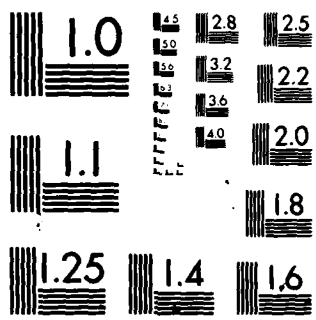

MICROCOPY RESOLUTION TEST CHART
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net benefits of executive/business, personal and aerial application use based on the previous sets of analyses. These per hour net benefit estimates are shown in Exhibit 3-33. In the case of executive and business net benefits, the averages are based on the averages of the benefits under the flexible and inflexible appointment scenarios for flights to New York.

By combining the figures in Exhibits 3-32 and 3-33, the net benefits of air taxi and rental activity are derived (see Exhibit 3-34). The consumer (surplus) benefits total to $280.1 million while the resource savings are approximately $144.5 million.

Interpreting Results

The fundamental assumptions underlying the air taxi and rental activity analyses are that the cost structures and activity profiles--distances flown, purpose of flights, income of passengers, etc.--are similar to those of owners/operators of business/executive, personal and aerial application aircraft. To the extent that these assumptions do not hold, the estimates are biased, but the direction of bias is unknown.

The assumption concerning similar cost structures is also worrisome because air taxi and rental aircraft may be used more intensively than owner/operator aircraft. If this is the case, the fixed costs of ownership can be spread over additional hours by air taxi and rental operators. Offsetting this tendency to some extent is the need for air taxi and rental operators to charge

Exhibit 3-33

AVERAGE NET BENEFITS BY AIRCRAFT TYPE AND USE CATEGORIES

	Average Net Benefits Per Hour of Operation			
	Business	Executive	Personal	Aerial Application
Single Engine Piston $\leq$ 3 Seats	-51.28	-	56.03	116.38
Single Engine Piston $\geq$ 3 Seats	21.71	15.40	82.71	-
Twin Piston	154.19	200.59	334.69	-
Turboprop	-	418.84	-	-
Turbojet	-	-355.92	-	-

Sources: Based on previous analyses of business/executive, personal and aerial application flights. The average per hour executive and business benefits are averages of the benefits under the flexible and inflexible appointment scenario for flights to New York.

Exhibit 3-34

NET BENEFITS OF AIR TAXI AND RENTAL ACTIVITY
($Millions)

	Air Taxi		Rental					
							Totals	
	Executive	Personal	Business	Executive	Personal	Aerial Application	Personal	Resource
Single Engine Piston ≤ 3 Seats	-.335	.338	-1.156	-	7.687	10.508	8.025	9.017
Single Engine Piston ≥ 3 Seats	6.678	33.110	12.156	.659	54.736	-	87.846	19.494
Twin Piston	116.746	178.811	8.090	9.409	4.413	-	184.223	134.246
Turboprop	32.902 -76.125	-	-	24.930	-	-	-	57.832
Turbojet	-76.125	-	-	-	-	-	-	76.125
TOTALS	79.866	212.259	19.090	34.998	66.836	10.508	280.094	144.464

Source: Based on previous analyses of business/executive, personal and aerial application flights. The average per hour executive and business benefits are averages of the benefits under the flexible and inflexible appointment scenario for flights to New York.

fees which include not only costs but also profits. While attempts were made to examine the impacts of these two tendencies, it quickly became apparent that any allocation of costs among multiple uses of air taxi and rental aircraft was per force arbitrary. Without case-by-case analysis of operator accounts, any such analysis seemed unsatisfactory. Thus, the assumption concerning the similarity of cost structures of owner/operators and air taxi/rental operators was retained.

INTERPRETING RESULTS

Even with ideal data, the measures of direct benefits described above are not without theoretical shortcomings. The more important of these are listed and discussed below.

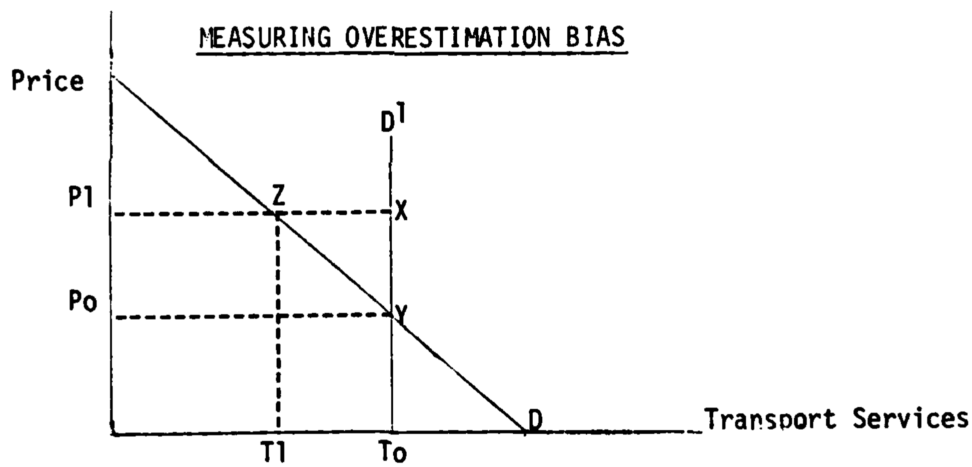
- o Direct benefits will be overestimated unless the demand for transportation is perfectly inelastic.
- o Without GA services, the burden placed on alternate modes may cause an increase in the marginal cost of transportation; in this case, direct benefits will be underestimated.
- o The benefits realized in 1977 were the result of years of investment in the GA industry, which a single-year accounting method fails to consider.
- o Changes in transportation costs are likely to cause a restructuring of route usage; in fact, the long-run impact of such disturbances may even cause relocations of origins and destinations (i.e., plants and markets).

Demand

The project team's accounting method assumes that substitute modes will produce the same quantity of transportation services, even though a smaller quantity may be demanded at a higher price. Exhibit 3-35 illustrates that this will cause an upward bias in our estimate of direct benefits. First, suppose that demand is perfectly inelastic (indicated by demand curve D^1). Let Po be the GA price of transport services and P1 be the price of the substitute. In this case, direct benefits will be correctly measured by the rectangular area P1 x YPo. However, if the true demand curve is not perfectly inelastic (indicated by curve D), then this rectangle will overestimate direct benefits since only T1 is demanded at price P1.[1] The problem, of course, is that T1 is never observed; hence it was impossible to correct for this bias.

Exhibit 3-35

MEASURING OVERESTIMATION BIAS



Marginal Cost

On the other hand, if the absence of the GA industry causes an increase in the marginal cost of alternate transport services,

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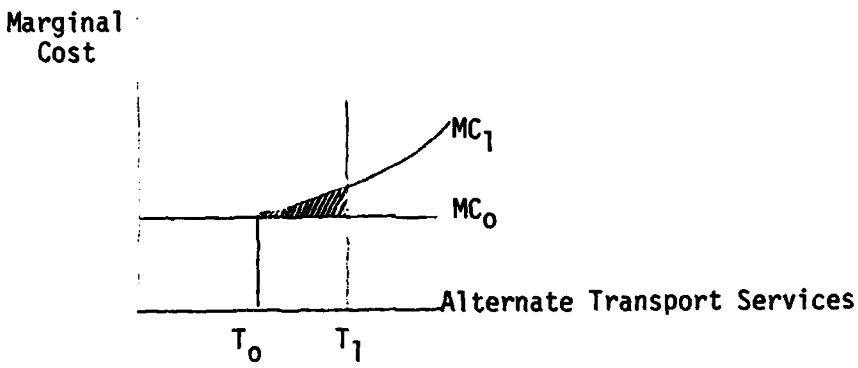
[1]By the theory of consumer surplus, the upward bias in the value of direct benefits will be given by triangle ZXY.

the measures of direct benefits will be biased downward. This is demonstrated in Exhibit 3-36.

Exhibit 3-36

CONSTANT VERSUS INCREASING MARGINAL COSTS



The method by which GRA measured direct benefits tacitly assumes that the marginal cost of providing alternate transport services is constant, as represented by MC_0 The absence of GA might increase the use of such services from T_0 to T_1. However, it has been assumed the marginal cost of providing unit T_1 of alternate transport services would exactly equal the marginal cost of providing unit T_0. It is more likely, though, that the curve representing the marginal cost of providing alternate transport services is upward sloping for at least some regions, perhaps as represented by MC_1. If such is the case, then the marginal cost of providing each unit after T_0 will increase. If T_1 units of alternate transportation are provided, then the GRA estimate of the total cost of providing such service will be underestimated by the shaded area. Direct benefits from GA, therefore, will also be underestimated by this amount.

However, a saving feature here is that this bias will tend to cancel the upward bias due to elastic demand. Of course, it would be highly speculative to conclude that the two biases cancel exactly.

Past Investment

The method of measuring direct benefits also fails to recognize that 1977 benefits accrue to a stream of investments over a long period of time. The foregone opportunity of alternative investment is relevant here. The theoretically correct procedure would be to calculate the flow of benefits minus net investment over the relevant time horizon and then compute the internal rate of return for the GA industry. Any alternative investment stream yielding a lower return would have been inferior, but not necessarily as inferior as our measure would indicate. However, given the scope of this study, the more correct procedure was not feasible because it would require the computation of net benefits for both GA and alternative investment schemes over a long period of time.

General Equilibrium Adjustments

As was previously mentioned, a change in the transport cost structure is likely to cause a reordering of route usage and the relocation of both points of departure and destinations as the economy adjusts to the alternative world. Ignoring this phenomenon will cause direct benefits to be overestimated since it will imply an inefficient adjustment to the absence of GA.

Robert Fogel, in his study of the railroad industry, writes:

> Forcing the pattern of shipments in the non-rail situation to conform to the pattern that actually existed is equivalent to the imposition of a restraint on society's freedom to adjust to an alternative technological situation. If society had to ship interregionally by water and wagon without the railroad, it could have shifted agricultural production from the Midwest to the East and South, and shifted some resources out of agriculture altogether.[2]

Mathematical optimization techniques to handle this sort of problem do exist; however, the heavy data requirements preclude estimation.

In summary, GRA has described four theoretical sources of bias in the methods for estimating direct benefits attributable to GA. Three of these--elastic demand, investment prior to 1977, and general equilibrium adjustments--produce upward biases. Increasing marginal transport costs will bias the estimate downward.

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[2]Fogel, R. W., Railroads and American Economic Growth, Baltimore, MD: The Johns Hopkins Press (1964).

APPENDIX A

SUMMARY OF NET BENEFITS OF BUSINESS AND EXECUTIVE FLIGHTS BY AIRCRAFT TYPE

Exhibit A-1

BENEFITS OF BUSINESS USE OF SINGLE-ENGINE PISTON AIRCRAFT, ONE TO THREE SEATS, BASED ON FLIGHTS TO NEW YORK

	Per Flight Benefits Based on VC of Operation			Flight Benefits Based on VC of Operation ($ Millions)	
Miles	1-Way Delay	2-Way Delay	Number of Flights	1-Way Delay	2-Way Delay
0-100	29.20	27.48	32,991	.96	.91
101-200	76.34	56.56	83,458	6.37	4.72
201-300	77.06	52.13	22,538	1.74	1.17
301-400	77.16	38.86	8,656	.67	.34
401-500	58.00	14.72	1,633	.09	.02
501-600	-34.63	-54.30	3,430	-.12	-.19
601-700	-38.81	-62.59	0	0	0
701-800	-57.18	-86.16	5,226	-.30	-.45
801-900	-79.39	-99.12	1,633	-.13	-.16
901-1000	-111.59	1128.25	3,430	-.38	-.44
		Flight Benefits		8.9	5.9
		Plus: Ground Transportation Advantage		3.8	3.8
		Adjusted Flight Benefits		12.7	9.7
		Less: Fixed Costs		-29.3	-29.3
		Net GA Benefit		-16.6	-19.6

Exhibit A-2

BENEFITS OF BUSINESS USE OF SINGLE-ENGINE PISTON AIRCRAFT, MORE THAN THREE SEATS, BASED ON FLIGHTS TO NEW YORK

	Per Flight Benefits Based on VC of Operation			Flight Benefits Based on VC of Operation ($ Millions)	
Miles	1-Way Delay	2-Way Delay	Number of Flights	1-Way Delay	2-Way Delay
0-100	69.56	66.37	129,238	8.99	8.58
101-200	188.62	147.94	838,470	158.18	124.04
201-300	219.88	162.41	564,684	124.16	91.71
301-400	255.02	164.45	254,536	64.91	41.86
401-500	235.52	134.77	143,310	33.75	19.31
501-600	112.18	63.55	36,362	4.08	2.31
601-700	139.91	73.23	36,362	5.08	2.66
701-800	49.54	-28.08	19,250	.95	-.54
801-900	10.16	-43.86	19,250	.20	-.84
901-1000	-37.70	-86.45	66,307	-2.4	-5.73
1001-1300	-74.86	-126.86	8,556	-.64	-1.08
		Flight Benefits		397.26	282.28
		Plus: Ground Transportation Advantage		102.58	102.58
		Adjusted Flight Benefits		499.84	384.86
		Less: Fixed Costs		344.57	344.57
		Net GA Benefit		155.27	40.29

Exhibit A-3

BENEFITS OF EXECUTIVE USE OF SINGLE-ENGINE PISTON AIRCRAFT, MORE THAN THREE SEATS, BASED ON FLIGHTS TO NEW YORK

	Per Flight Benefits Based on VC of Operation			Flight Benefits Based on VC of Operation ($ Millions)	
Miles	1-Way Delay	2-Way Delay	Number of Flights	1-Way Delay	2-Way Delay
0-100	57.37	54.19	11,606	.67	.63
101-200	154.34	113.93	64,708	9.99	7.37
201-300	163.71	106.60	43,155	7.06	4.60
301-400	177.31	90.37	19,452	3.45	1.76
401-500	135.99	38.61	10,952	1.50	.42
501-600	-6.63	-56.32	2,779	-.02	-.16
601-700	-1.44	-65.83	2,779	-.004	-.18
701-800	-116.14	-189.85	1,471	-.17	-.28
801-900	-175.59	-224.98	1,471	-.26	-.33
901-1000	-242.54	-290.33	5,067	-1.23	-1.47
1001-1300	-320.84	-364.64	654	-.21	- .24
		Flight Benefits		20.78	12.12
		Plus: Ground Transportation Advantage		7.84	7.84
		On-Site Airport Time Advantage of Executive Flying		7.34	7.34
		Adjusted Flight Benefits		35.96	27.30
		Less: Fixed Costs		26.25	26.25
		Net GA Benefit		9.71	1.05

Exhibit A-4

BENEFITS OF BUSINESS USE OF TWIN-PISTON AIRCRAFT
BASED ON FLIGHTS TO NEW YORK

	Per Flight Benefits Based on VC of Operation			Flight Benefits Based on VC of Operation ($ Millions)	
Miles	1-Way Delay	2-Way Delay	Number of Flights	1-Way Delay	2-Way Delay
0-100	161.18	151.06	4,702	.76	.91
101-250	470.74	358.41	633,622	287.27	227.10
251-500	570.00	389.54	514,891	293.49	200.57
501-1300	251.84	104.13	16,458	4.14	1.71
1201-2600	-181.59	-292.60	15,282	-2.78	-4.47
		Flight Benefits		593.88	425.62
		Plus: Ground Transportation Advantage		108.48	108.48
		Adjusted Flight Benefits		702.36	534.10
		Less: Fixed Costs		247.59	297.59
		Net GA Benefit		404.77	236.51

Exhibit A-5

BENEFITS OF EXECUTIVE USE OF TWIN-PISTON AIRCRAFT

BASED ON FLIGHTS TO NEW YORK

Miles	Per Flight Benefits Based on VC of Operation: 1-Way Delay	Per Flight Benefits Based on VC of Operation: 2-Way Delay	Number of Flights	Flight Benefits Based on VC of Operation ($ Millions): 1-Way Delay	Flight Benefits Based on VC of Operation ($ Millions): 2-Way Delay
0-100	145.20	135.37	4,203	.61	.57
101-250	403.44	296.05	566,420	228.52	167.69
251-500	468.85	293.38	460,282	215.80	135.04
501-1300	-9.41	-146.68	14,712	-.14	-2.16
1301-2600	-712.76	-831.18	13,661	-9.74	-11.35
		Flight Benefits		435.05	289.79
		Plus: Ground Transportation Advantage		96.97	96.97
		On-Site Airport Time Advantage of Executive Flying		105.91	105.91
		Adjusted Flight Benefits		637.93	492.67
		Less: Fixed Costs		264.90	264.90
		Net GA Benefit		373.03	227.77

Exhibit A-6

BENEFITS OF EXECUTIVE USE OF TURBOPROP AIRCRAFT
BASED ON FLIGHTS TO NEW YORK

	Per Flight Benefits Based on VC of Operation			Flight Benefits Based on VC of Operation ($ Millions)	
Miles	1-Way Delay	2-Way Delay	Number of Flights	1-Way Delay	2-Way Delay
0-100	227.58	213.52	3,199	.73	.68
101-250	600.52	494.13	308,357	203.68	152.37
251-500	800.48	540.85	296,201	237.10	160.20
501-1200	286.49	35.64	15,994	4.58	.57
1201-2600	-649.84	-910.67	15,994	-10.39	-14.65
		Flight Benefits		435.70	299.17
		Plus: Ground Transportation Advantage		87.28	87.28
		On-Site Airport Time Advantage of Executive Flying		96.70	96.70
		Adjusted Flight Benefit		619.68	483.15
		Less: Fixed Costs		211.74	211.74
		Net GA Benefit		407.94	271.41

Exhibit A-7

BENEFITS OF EXECUTIVE USE OF TURBOJET AIRCRAFT BASED ON FLIGHTS TO NEW YORK

	Per Flight Benefits Based on VC of Operation			Flight Benefits Based on VC of Operation ($ Millions)	
Miles	1-Way Delay	2-Way Delay	Number of Flights	1-Way Delay	2-Way Delay
0-100	184.91	171.12	0	0	0
101-250	500.36	356.84	9,508	4.76	3.39
251-500	557.35	312.34	204,226	113.83	63.79
501-800	182.95	-115.95	100,046	18.30	-11.60
801-2600	-1057.48	-1582.88	100,046	-105.80	-158.36
		Flight Benefits		31.09	-102.78
		On-Site Airport Time Advantage of Executive Flying		59.20	59.20
		Adjusted Flight Benefits		126.61	-7.26
		Less: Fixed Costs		258.26	258.26
		Net GA Benefit		-131.65	-265.52

Exhibit A-8

BENEFITS OF BUSINESS USE OF SINGLE-ENGINE PISTON AIRCRAFT, ONE TO THREE SEATS BASED ON FLIGHTS TO MINNEAPOLIS

	Per Flight Benefits Based on VC of Operation			Flight Benefits Based on VC of Operation ($ Millions)	
Miles	1-Way Delay	2-Way Delay	Number of Flights	1-Way Delay	2-Way Delay
0-100	43.81	38.04	32,991	1.44	1.25
101-200	109.60	87.99	83,458	9.15	7.34
201-300	99.17	64.02	22,538	2.23	1.44
301-400	108.92	75.79	8,656	.94	0.66
401-500	84.75	39.35	1,673	.14	.06
501-600	-13.64	-34.64	3,430	-.05	-.12
601-700	-21.08	-46.49	0	-	-
701-800	-11.44	-41.50	5,226	-.06	-.22
801-900	31.44	12.55	1,633	.05	.02
901-1000	-57.00	-69.13	3,430	-.20	-.24
		Flight Benefits		13.64	10.19
		Plus: Ground Transportation Advantage		3.80	3.80
		Adjusted Flight Benefit		17.44	13.99
		Less: Fixed Costs		-29.30	-29.30
		Net GA Benefit		-11.86	-15.31

Exhibit A-9

BENEFITS OF BUSINESS USE OF SINGLE-ENGINE PISTON AIRCRAFT, MORE THAN THREE SEATS BASED ON FLIGHTS TO MINNEAPOLIS

Miles	Per Flight Benefits Based on VC of Operation: 1-Way Delay	Per Flight Benefits Based on VC of Operation: 2-Way Delay	Number of Flights	Flight Benefits Based on VC of Operation ($ Millions): 1-Way Delay	Flight Benefits Based on VC of Operation ($ Millions): 2-Way Delay
0-100	101.60	92.42	151,858	15.43	14.03
101-200	258.79	212.39	838,433	216.98	178.07
201-300	264.95	183.68	564,659	149.61	103.72
301-400	306.47	232.64	254,524	78.00	59.21
401-500	291.83	185.43	143,304	41.82	26.57
501-600	153.98	96.60	36,361	5.59	3.51
601-700	139.36	69.58	36,361	5.06	2.53
701-800	155.30	52.35	19,250	2.99	1.01
801-900	227.31	160.53	19,250	4.38	3.09
901-1000	105.62	77.96	66,305	7.00	5.17
1001-1300	23.65	-34.80	8,555	.20	-.30
		Flight Benefits		527.06	396.61
		Plus: Ground Transportation Advantage		102.58	102.58
		Adjusted Flight Benefits		629.64	499.19
		Less: Fixed Costs		344.57	344.57
		Net GA Benefit		285.07	154.62

Exhibit A-10

BENEFITS OF EXECUTIVE USE OF SINGLE-ENGINE PISTON AIRCRAFT, MORE THAN THREE SEATS
BASED ON FLIGHTS TO MINNEAPOLIS

	Per Flight Benefits Based on VC of Operation			Flight Benefits Based on VC of Operation ($ Millions)	
Miles	1-Way Delay	2-Way Delay	Number of Flights	1-Way Delay	2-Way Delay
0-100	86.21	76.96	11,606	1.00	.89
101-200	221.42	175.67	64,708	14.32	11.37
201-300	203.42	124.59	43,155	8.78	5.38
301-400	226.82	160.30	19,452	4.41	3.12
401-500	197.02	91.79	10,952	2.16	1.01
501-600	37.02	-18.53	2,779	.10	-.05
601-700	-6.56	-70.36	2,779	-.02	-.20
701-800	-4.40	-107.58	1,471	-.006	-.16
801-900	46.24	-23.62	1,471	.07	-.03
901-1000	-146.19	-195.42	5,067	-.74	-.99
1001-1300	-221.73	-.256.68	654	-.15	-.17
		Flight Benefits		29.92	20.17
		Plus: Ground Transportation Advantage		7.84	7.84
		On-Site Airport Time Advantage of Executive Flying		7.34	7.34
		Adjusted Flight Benefits		45.10	35.35
		Less Fixed Costs		26.25	26.25
		Net GA Benefits		18.85	9.10

Exhibit A-11

BENEFITS OF BUSINESS USE OF TWIN-PISTON AIRCRAFT BASED ON FLIGHTS TO MINNEAPOLIS

Miles	Per Flight Benefits Based on VC of Operation		Number of Flights	Flight Benefits Based on VC of Operation ($ Millions)	
	1-Way Delay	2-Way Delay		1-Way Delay	2-Way Delay
0-100	230.68	206.40	4,702	1.08	.97
101-250	537.49	399.79	633,622	340.57	253.32
251-500	718.43	507.00	514,891	369.61	261.05
501-1300	436.01	245.86	16,458	7.17	4.05
1301-2600	-56.48	-166.38	15,282	-.86	-2.54
		Flight Benefits		717.57	516.85
		Plus: Ground Transportation Advantage		108.48	108.48
		Adjusted Flight Benefits		826.05	625.33
		Less: Fixed Costs		297.59	297.59
		Net GA Benefit		528.46	327.74

Exhibit A-12

BENEFITS OF EXECUTIVE USE OF TWIN-PISTON AIRCRAFT

BASED ON FLIGHTS TO MINNEAPOLIS

	Per Flight Benefits Based on VC of Operation			Flight Benefits Based on VC of Operation ($ Millions)	
Miles	1-Way Delay	2-Way Delay	Number of Flights	1-Way Delay	2-Way Delay
0-100	210.86	186.77	4,203	.89	.78
101-250	477.03	338.82	566,420	270.20	191.91
251-500	617.16	411.35	460,282	284.07	189.34
501-1300	179.91	.39	14,712	2.65	.01
1301-2600	-462.54	-561.68	13,661	-6.32	-7.67
		Flight Benefits		551.49	374.37
		Plus: Ground Transportation Advantage		96.97	96.97
		On-Site Airport Time Advantage of Executive Flying		105.91	105.91
		Adjusted Flight Benefits		754.37	577.25
		Less Fixed Costs		264.90	264.90
		Net GA Benefit		489.47	312.35

Exhibit A-13

BENEFITS OF EXECUTIVE USE OF TURBOPROP AIRCRAFT BASED ON FLIGHTS TO MINNEAPOLIS

Miles	Per Flight Benefits Based on VC of Operation		Number of Flights	Flight Benefits Based on VC of Operation ($ Millions)	
	1-Way Delay	2-Way Delay		1-Way Delay	2-Way Delay
0-100	326.03	295.12	3,199	1.04	.94
101-250	766.58	554.24	308,357	236.38	170.90
251.500	1005.22	706.64	296,201	297.75	209.31
501-1200	597.27	282.19	15,994	9.55	4.51
1201-2600	-330.00	-533.33	15,994	-5.28	-8.53
		Flight Benefits		539.44	377.13
		Plus: Ground Transportation Advantage		87.28	87.28
		On-Site Airport Time Advantage of Executive Flying		96.70	96.70
		Adjusted Flight Benefits		723.42	561.11
		Less: Fixed Costs		211.74	211.74
		Net GA Benefit		511.68	349.39

Exhibit A-14

BENEFITS OF EXECUTIVE USE OF TURBOJET AIRCRAFT
BASED ON FLIGHTS TO MINNEAPOLIS

	Per Flight Benefits Based on VC of Operation			Flight Benefits Based on VC of Operation ($ Millions)	
Miles	1-Way Delay	2-Way Delay	Number of Flights	1-Way Delay	2-Way Delay
0-100	270.32	240.76	0	0	0
101-250	626.84	393.28	9,508	5.96	3.74
251-500	783.47	451.19	204,226	160.00	92.14
501-800	393.67	21.46	100,046	34.38	21.47
801-2600	-441.58	-902.66	100,046	-44.18	-90.90
		Flight Benefits		161.16	27.05
		Plus: Ground Transportation Advantage		36.32	36.32
		On-Site Airport Time Advantage of Executive Flying		59.20	59.20
		Adjusted Flight Benefits		256.68	122.57
		Less: Fixed Costs		258.26	258.26
		Net GA Benefits		-1.58	-135.69

APPENDIX B

REGRESSION EQUATIONS UTILIZED TO ESTIMATE CONSUMER BENEFITS OF PERSONAL USE

A/C Type 1--SPL3S:

Regression:

$$HRS = 1.711 - \underset{(4.59)}{.031}\ ATC + \underset{(7.26)}{.0035}\ DPI_{-1}$$

$$\overline{R}^2 = .782$$

Elasticity:

$$E_{\overline{ATC}} = \frac{\partial HRS}{\partial ATC} \cdot \frac{\overline{ATC}}{\overline{HRS}} = -.031\left(\frac{52.68}{1.958}\right) = -.834$$

Suppressing DPI_{-1} (=694.72):

$$HRS = 4.14 - .031\ ATC$$

$$ATC = 133.63 \text{ if } HRS = 0$$

Consumer Surplus:

$$CS = .5\,[(133.63 - 72.04) \times 2.118]$$

$$= \$65.224\ M \text{ or } \$118.381\ M\ (1977\ \$\text{'s})$$

Average Income Required to Generate C.S.:

Ave. Income = $33,317

A/C Type 2--SPG3S

Regression:

$$HRS = 1.6681 - \underset{(2.98)}{.0659}\ ATC + \underset{(14.86)}{.01198}\ DPI_{-1}$$

$$\bar{R}^2 = .958$$

Elasticity:

$$E_{\overline{ATC}} = -.717$$

Suppressing DPI_{-1}:

$$HRS = 9.991 - .0659\ ATC$$

$$ATC = 151.61 \text{ if } HRS = 0$$

Consumer Surplus:

$$CS = .5\ [(151.61 - 59.43) \times 5.830]$$

$$= \$268.705\text{ M or }\$487.70\text{ M (1977 \$'s)}$$

Average Income Required to Generate C.S.:

Ave. Income = $46,360

A/C Type 3--TEP < 12,500 lbs.

Regression:

$$HRS = -61.1112 - \underset{(1.865)}{1.2964}\ ATC + \underset{(9.145)}{1.0925}\ DPI_{-1}$$

$$\bar{R}^2 = .923$$

Elasticity:

$$E_{\overline{ATC}} = -.595$$

Suppressing DPI_{-1}:

$$HRS = 697.869 - 1.2964\ ATC$$

or

$$ATC = 538.31 \text{ if } HRS = 0$$

Consumer Surplus:

$$CS = .5\ [(538.31 - 192.95) \times .490]$$

$$= \$84.697\ M \text{ or } \$153.73\ M\ (1977\ \$\text{'s})$$

Average Income Required to Generate C.S.:

Ave. Income = $78,575


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